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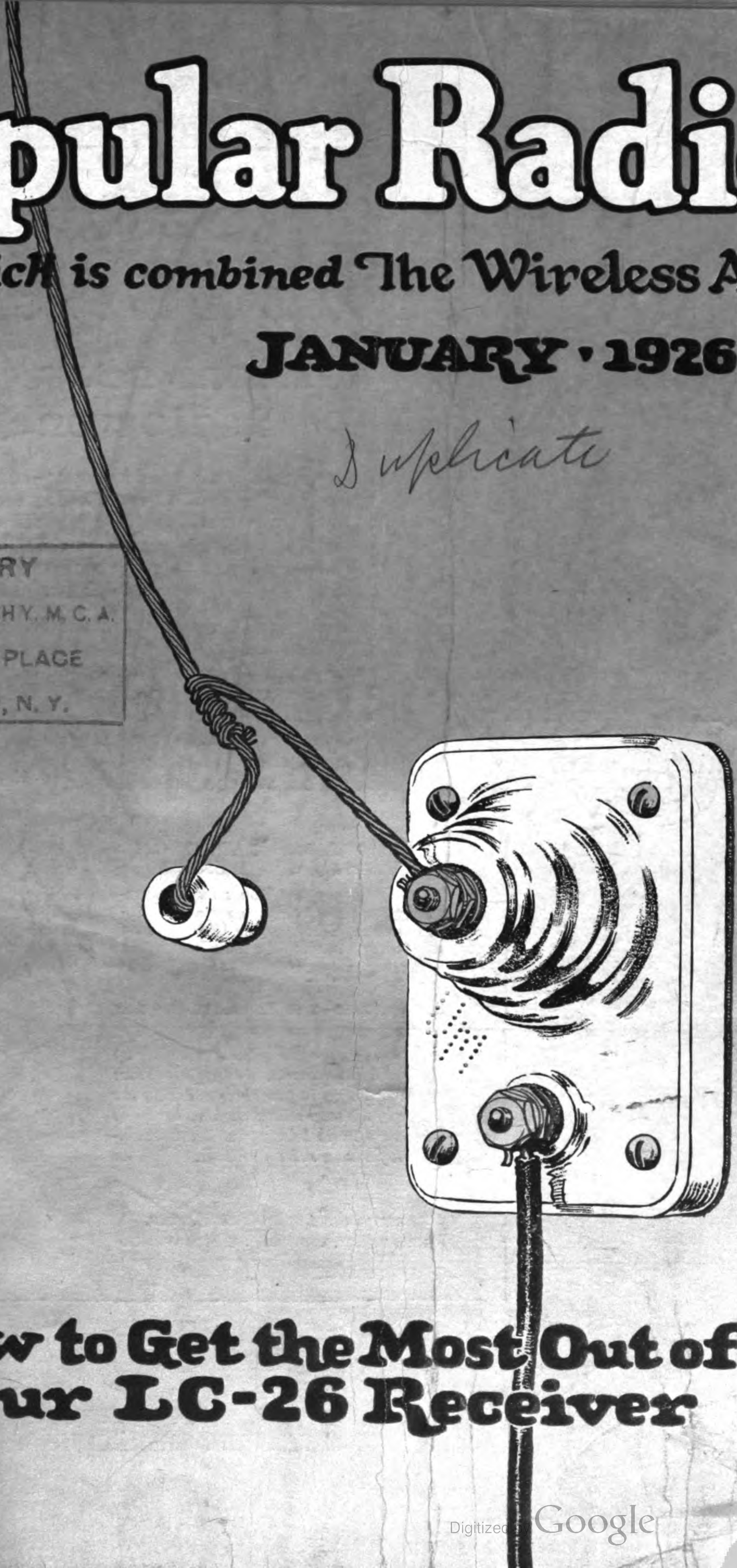

How to Get the Most Out of Your LC-26 Receiver

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Drive a car uphill beyond its power—and the motor knocks. Drive a radio set beyond its power—and the last tube chokes. But change one single tube in the set—and you have the power you need for *greater volume* and *finer tone.*

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The new storage battery power Radiotron UX-112 may be used in sets that use Radiotron UV-201-A.

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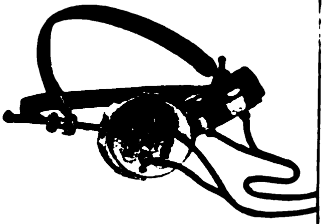

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Send for an interesting booklet describing Acoustics by Brandes.

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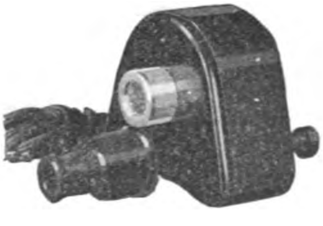
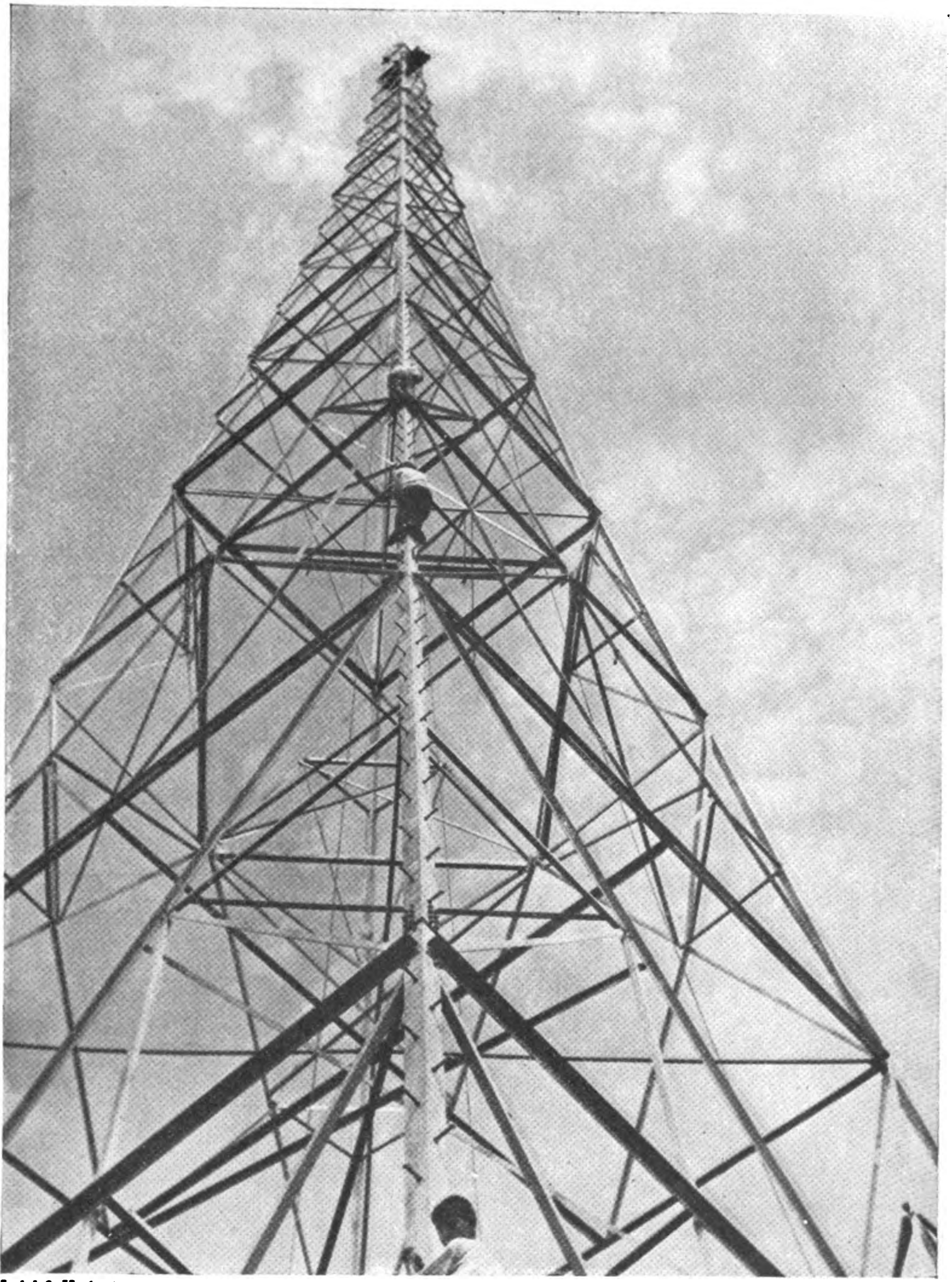


The Phonograph Attachment — a splendid speaker with any good phonograph. Same unit as type H horn. Adjustable and furnished with a connection to fit all phonographs.

The new Brandes Speakers—perfected now after many busy years of experiment—give new clarified mellowness to the low tones, new rounded sweetness to the high.

Be sure your set is in its best voice—always—with acoustics by Brandes.



Kadel & Herbert

The Modern Tower of Babel

"I will lead them in paths that they have not known; I will make darkness light before them, and crooked things straight."

—ISAIAH, 42:16.

Popular Radio

WITH WHICH IS COMBINED "THE WIRELESS AGE"

VOLUME IX JANUARY, 1926 NUMBER 1

The New Wave-Transmission Phonograph

ONE of the most important advances made in the science of sound is the creation of the new talking machine that involves the use of mechanical apparatus and principles developed by radio engineers. This article, which has been prepared exclusively for POPULAR RADIO, reveals for the first time the scientific details of this invention.

By HENRY C. HARRISON

DEVELOPMENT of a new mechanical phonograph by electrical engineers working in Bell Telephone Laboratories is a natural result of their recent applications of electrical theory to mechanical problems.

Since the inception of the telephone, the development work on it has passed through a number of stages. In the pioneer days, the method was necessarily that of guess-and-trial, guided by good judgment and such theory as was then available.

In the field of telephony these many experiments led to satisfactory conversation over only moderate but constantly increasing distances, even as great as between New York and Denver. During these years, however, the theory of electrical transmission was being developed gradually by various mathematical physicists. A little more than ten years ago it reached such a stage that the mathematical method of design replaced the pioneer method of trial so far as electrical circuits were concerned. It then became possible to design telephone lines of any length so that they would have pre-computed qualities.

In recent years these theoretical methods of designing electrical lines have been made the basis of theoretical methods of designing the vibrating parts of such mechanical systems as telephone receivers and transmitters.

Still more recently, these methods of design have been applied to the phonograph.

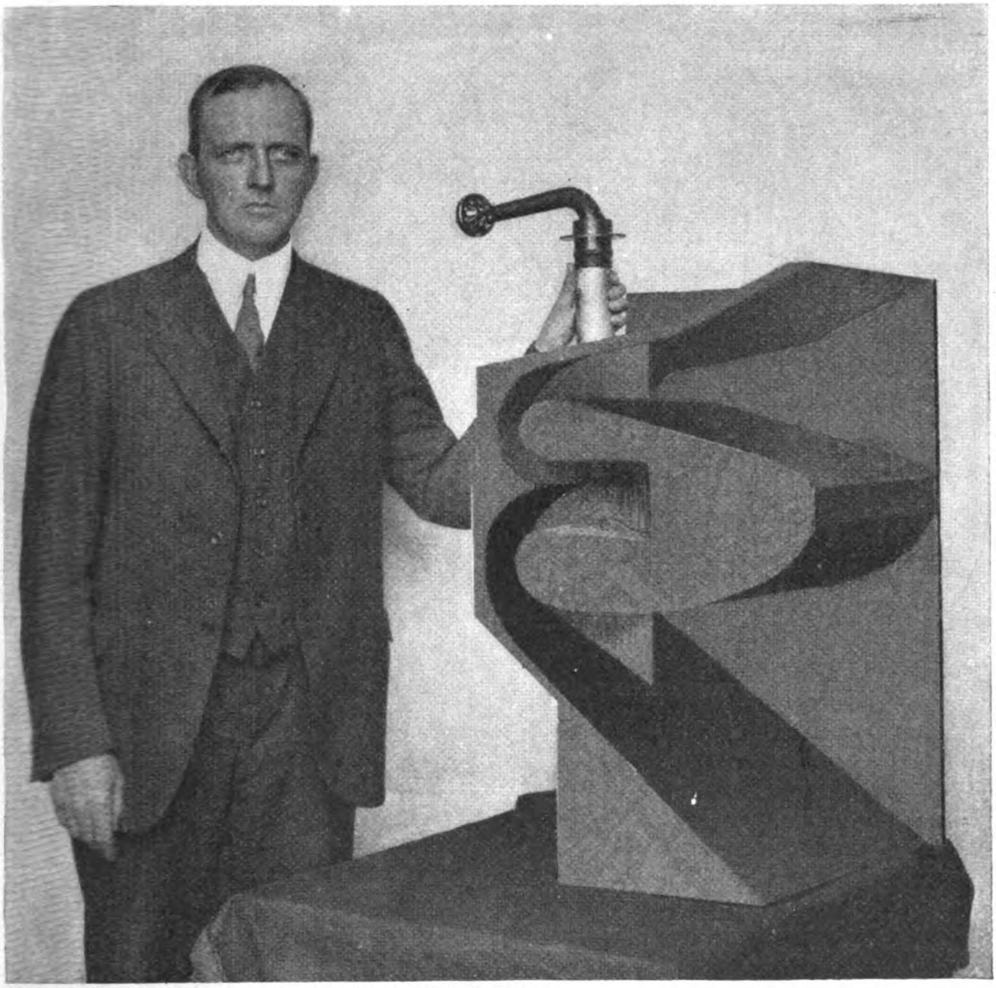
It was recognition of the fact that a phonograph is a mechanical system for transmitting wave energy that led to the application of electrical wave-transmission theory to it. With this method of design, it has been a fairly simple matter to calculate just what requirements each part of the phonograph must meet, and with these requirements known, it has been a matter of comparatively few experiments to obtain nearly perfect reproduction.

The quality of reproduction given by the new phonograph, as compared with that of previous construction, is more readily demonstrated to the ear than described in words. Some idea of the improvement, however, may be formed from the fact that a talking machine that embodies this new principle reproduces five and one-half octaves, whereas the older type reproduces about three octaves, and the phonograph of twenty years ago something of the order of one octave. Listening to the machine, one hears the low-frequency tones as well as the high ones. Its reproduction of these low frequencies gives naturalness to speech and music, makes it comfortable to the ear and carries over the full power of the rhythm. At the other end of the scale the machine's reproduction of high frequencies gives clarity and detail. They move the "master's voice" from a position hidden behind the horn right out into the room. They make all the instruments in an orchestra stand out individually, each with its own peculiar quality of tone.

On the new phonograph, not only is the full range of frequencies reproduced but it is reproduced without perceptible peaks or valleys; that is, without the regions of exaggerated loudness or weakness in different parts of the frequency range. An example of a peak is what one hears when one speaks with his head in a barrel; an example of a valley is

The Newly Discovered Facts About Sound

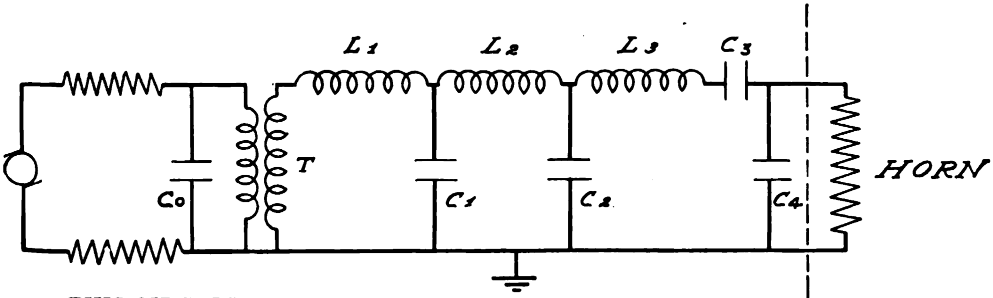
The fundamental thing about radio is the handling of wave energy, of vibrations. Two kinds of waves are involved. From the loudspeakers and telephones come the mechanical waves of sound. In the electrical parts of radio instruments, as well as in the ether, the waves are electromagnetic ones. Many of the principles are the same. In this article Mr. Harrison describes the application of wave-energy principles to the acoustic problem of designing a high-quality phonograph. This involves "mechanical impedance," "mechanical transformers," other novel concepts which will interest every radio engineer. The research constitutes, POPULAR RADIO believes, one of the greatest recent advances in the science of sound. Facts uncovered by the telephone engineers were put at the disposal of the talking machine interests, whose researches have put them in position where the new technique could be appreciated and applied. Thus radio, often accused of having damaged the phonograph industry, actually contributes one of the greatest advances which that industry has ever made.



From a photograph made for POPULAR RADIO by the Bell Laboratories

THE INVENTOR OF THE APPARATUS

Mr. Henry C. Harrison with the acoustic system of the new orthophonic talking machine. Note how the internal partitions fold the horn so that a greater length can be contained in the case of the instrument.

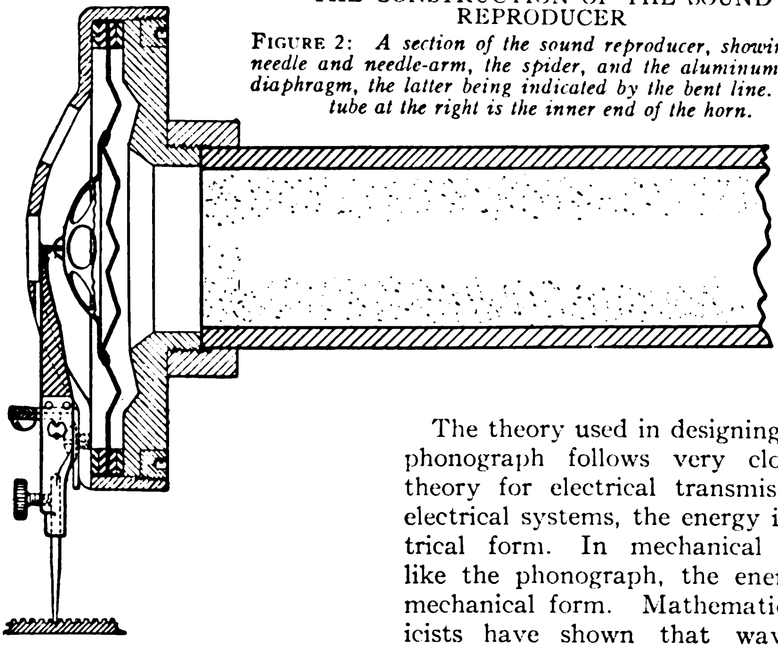


THIS CIRCUIT IS THE ELECTRICAL ANALOGUE OF THE NEW ACOUSTIC SYSTEM

FIGURE 1: *The alternator represents the input from the record; L_1 is the mass of the needle arm; L_2 that of the spider, and L_3 that of the diaphragm. T is a transformer corresponding to the needle-arm leverage: C_0 the elasticity of the needlepoint, C_1 that of the needle arm, C_2 that of the spider arms, C_3 that of the diaphragm edge and C_4 that of the air chamber.*

THE CONSTRUCTION OF THE SOUND REPRODUCER

FIGURE 2: *A section of the sound reproducer, showing the needle and needle-arm, the spider, and the aluminum-alloy diaphragm, the latter being indicated by the bent line. The tube at the right is the inner end of the horn.*



what one hears in the voice of a person with a bad cold.

In scientific language, these changes in quality are expressed as changes in the distribution of sound intensity with frequency. From this viewpoint, speech and music are made up of simple flute-like tones of various pitches and various intensities. For example, the different vowels of speech are distinguished from each other, not by their fundamental frequency, but solely by the distribution of intensity among their overtones. Because elements of speech have this character, one may speak into a barrel of just the right size and find that when he speaks one vowel a different one is heard. A phonograph with the same peak will make the same change.

Similarly, a phonograph with "valleys" which rob the reproduction of the frequency range belonging to the resonant cavities of the head which are choked up during a cold makes a singer or speaker sound as though he had a bad cold. The phonographs of twenty years ago abounded in these peaks and valleys. The new phonograph is practically free from these defects.

The theory used in designing the new phonograph follows very closely the theory for electrical transmission. In electrical systems, the energy is in electrical form. In mechanical systems, like the phonograph, the energy is in mechanical form. Mathematical physicists have shown that wave-energy formulas worked out in one field apply to the other field with simply a change in nomenclature. The corresponding terms in the two fields are as follows:

Mechanical	*Electrical*
Displacement (total movement)	Charge
Velocity of displacement	Current
Force	Potential (voltage)
Mass	Inductance
Elasticity	Reciprocal of capacity
Mechanical resistance (frictional loss)	Resistance

In designing high quality wave transmission systems, either electrical or mechanical, the important matter is matching impedance throughout the system.

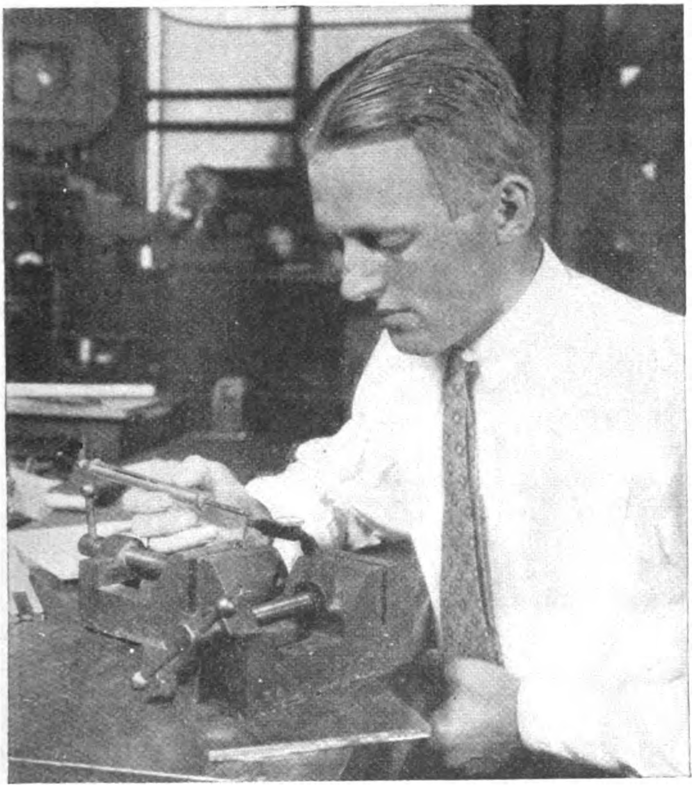
This means that each part of the system then offers to the wave energy a path of equal ease of flow, so that its flow through the system proceeds without any reflection. Thus there are no resonance peaks. Even structures which are apparently so different as needle arms, diaphragms and horns can be substantially matched in mechanical impedance to the wave energy.

In addition to preventing internal reflection and consequent peaks, matching impedance gives a phonograph a substantially uniform mechanical resistance. Hence the power taken from the record groove is proportional to the transverse velocity of the groove squared. And since this full energy is transmitted out into the air, the result is faithful reproduction. The older phonographs are not matched in impedance. They neither take correct amounts of power from the record nor transmit this power to the air without reflection and resonance peaks. In addition to giving faithful reproduction, the matching of impedance reduces the wear on the records because the resonance points, with associated high pressure of the needle point against the record groove, are eliminated.

As the first step in designing a matched impedance phonograph, the diagram of mechanical impedances is needed.

Figures 1 and 2 are sketches of an acoustic phonograph and of its mechanical impedance diagram.

In Figure 1, the same symbols are used for mass, elasticity, and mechanical resistance as are commonly used in electrical impedance diagrams for inductance, capacity, and electrical resistance.* These quantities are corresponding ones as respects the storage or dissipation of energy; hence they have corresponding effects on the transmission of wave energy. The system is shown with its shunt branches working into substantially free space. Actually, the branches work into air, but because of their small size compared with the wave-



MEASURING THE ELASTICITY OF THE NEEDLE-ARM

Mr. Arthur Bates is making one of the fundamental measurements upon which the phonograph design depends. In mechanical wave systems elasticity is the equivalent of the reciprocal of capacity in electrical systems.

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* In this diagram certain second-order effects are omitted for the sake of clearness. The complete diagram and a full description of the technical features will appear in a paper to be presented at the Midwinter Convention of the American Institute of Electrical Engineers.

PIONEERS IN THE APPLICATION OF MATHEMATICS TO THE PHONOGRAPH

Mr. Harrison (at the left) is holding the sound reproducer which he is explaining to Mr. Joseph P. Maxfield, who developed the electrical methods by which high quality records are made for use with the new machine. In the foreground lies one of the aluminum-alloy diaphragms.

lengths in air of speech frequencies, the air acts like free space. In a mechanical system free space is analogous to an infinite capacity, or "ground," in an electrical system.

The shunt branches of the line are ones through which vibration velocity, that is, the mechanical current, flows from the main line to space. The series elements in the line are ones through which all of the line mechanical current must pass. The symbol used for a mechanical transformer is the one usually used in electrical circuits and indicates merely a change in displacement velocities at this point.

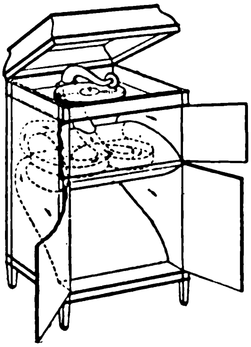
The term "mechanical current" is used as meaning the root mean square of vibration velocity in centimeters per second. The term "alternating force" is used as meaning the root mean square of forces, in dynes, tending to set up or vary mechanical currents. By the "mass of a part" is meant the mass in grams which, located at the point at which the part ties into the mechanical line, would have the same kinetic energy as the part. Similarly, by the "elasticity" of a part is meant the elasticity in dynes per centimeter which, located at the point of attachment, would store the same potential energy as the part.

It is evident from these diagrams that the first three sections of this network constitute a transmission system of the low-pass filter type and hence will have a high frequency cut-off. The series elasticity, due to the diaphragm edge, does not belong in a low-pass filter and interferes with the transmission of the lower voice frequencies unless very small.

The principles and formulas that govern transmission networks such as this one are worked out for analogous electrical lines by J. A. Fleming, A. E. Kennelly, and George A. Campbell. Building upon the foundation these scientists have laid, the telephone engineers were able to treat the design of an acoustic phonograph as an engineering problem. Certain results were desired, certain limitations had to be met as to materials and dimensions, and certain other factors might be varied practically at will. Calculations were made for the various parts, and these were checked by measurements of the characteristics of the parts as vibrating elements. Here an entirely new technique was developed, as for instance the direct measurement of mechanical impedances over a range of frequencies.

Thus it was possible for the mechanical impedances of the different parts of the system to be carefully matched, just as should be done to the electrical wave-energy circuits used in telephony or in the parts of radio apparatus.

From a photograph made for POPULAR RADIO by Victor Talking Machine Co.



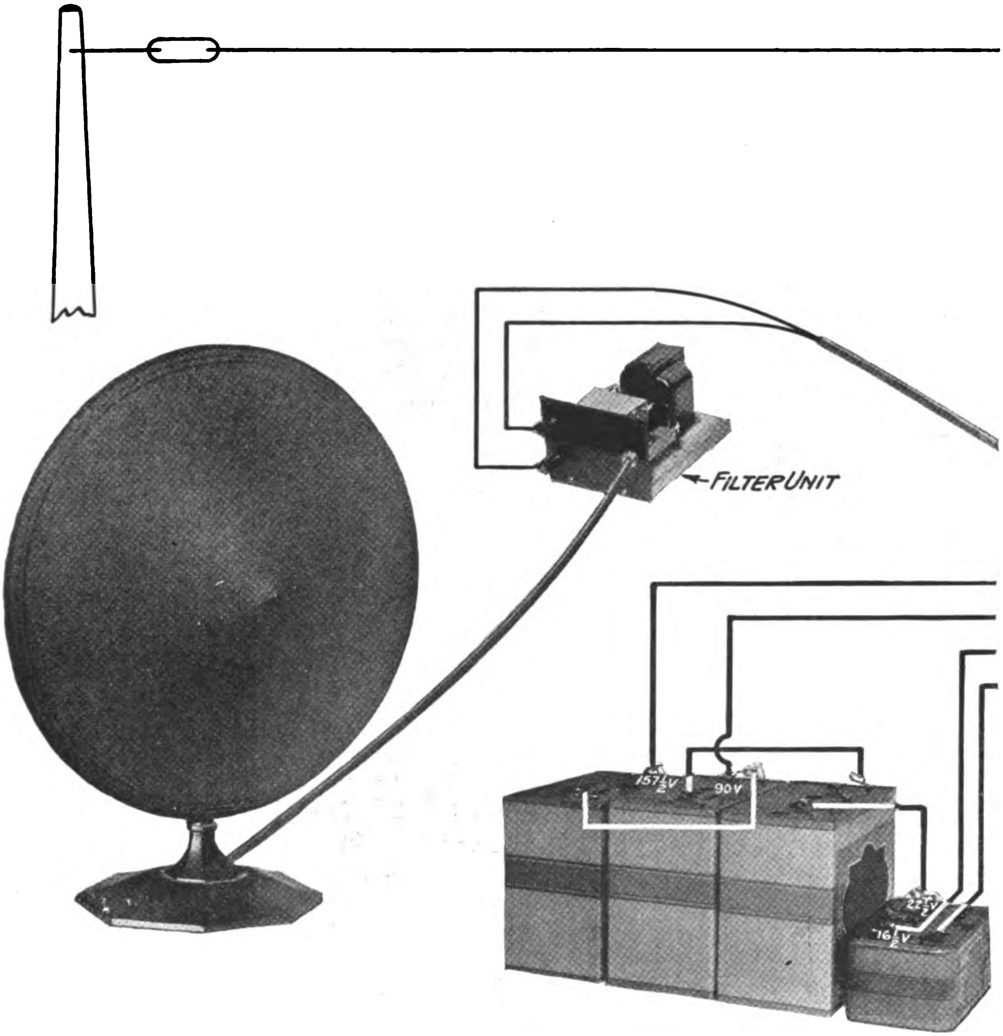
THE COMPLETED MACHINE

In the small diagram at the right is shown the arrangement of the gradually widening passages through which the sound waves travel. Note the great length (70 inches) of the new horn, as compared with the older and more familiar types. Above, Reinald Werrenrath, the grand opera singer, is seen listening to a record of his own voice on one of the first machines to be completed.

¶ IN POPULAR RADIO *for next month—February—will appear the complete, detailed specifications for building one of the latest and most efficient sets that have been developed—the Orthophase Receiver.*

HOW TO GET THE MOST

By S. GORDON TAYLOR and L. M. COCKADAY



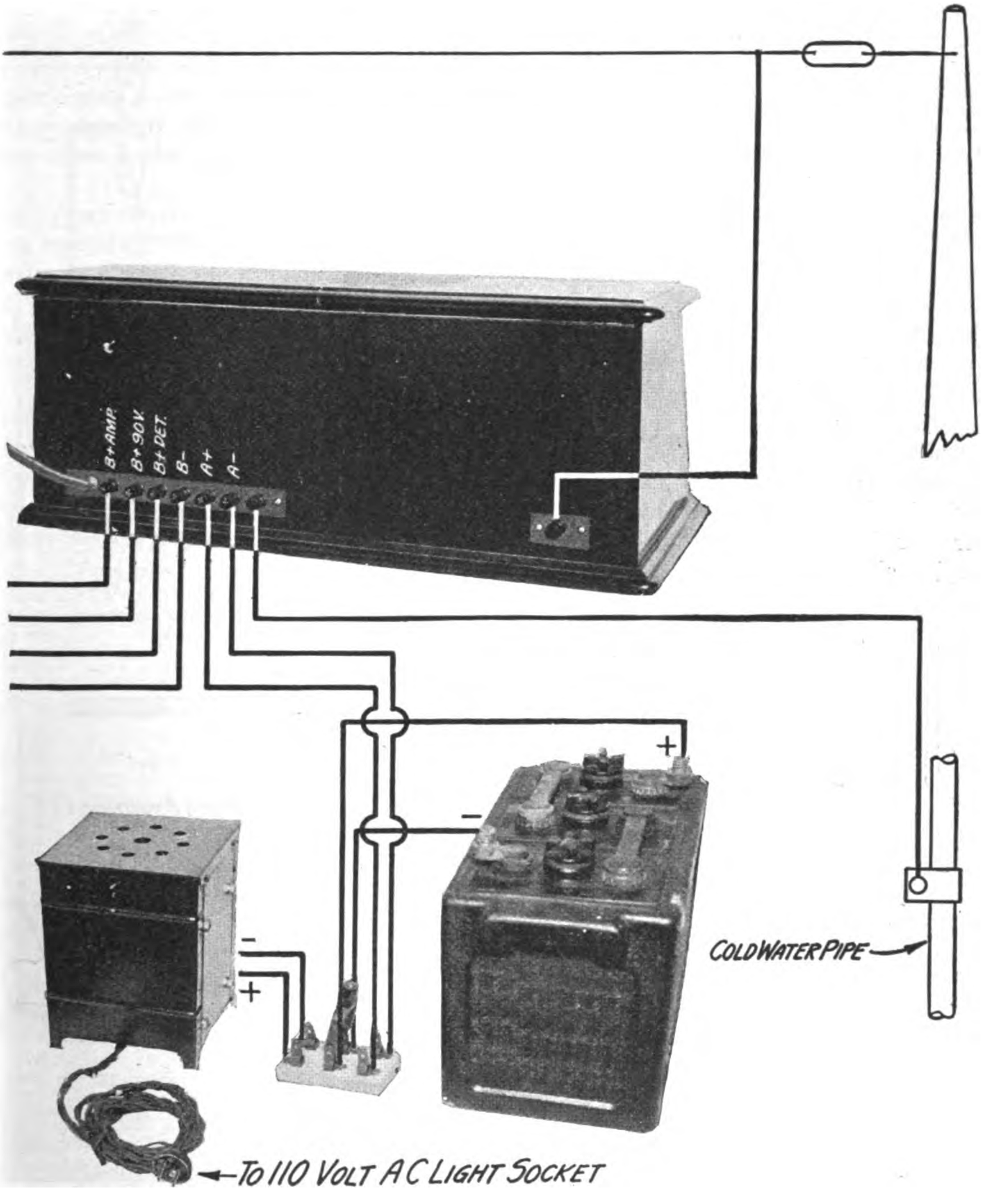
SO great has been the interest shown on the part of readers of POPULAR RADIO, and so keen has been the competition among radio fans and experimenters to be one of the first to build one of the new LC-26 receivers and to get it in operation, that this article—which takes the place of the "How to Get the Most Out of Your Ready-made Receiver" article that would ordinarily appear in this issue—follows by popular demand.

To test the capacities of this receiver the authors have taken it to a number of cities in the East and experimented with actual receiving conditions for the purpose of telling experimenters who have built this set exactly what to do when they install and operate it.

First of all, let us start with a general description of the receiver.

It uses a simple antenna circuit that is easily resonated over the whole band of

OUT OF YOUR LC-26 SET



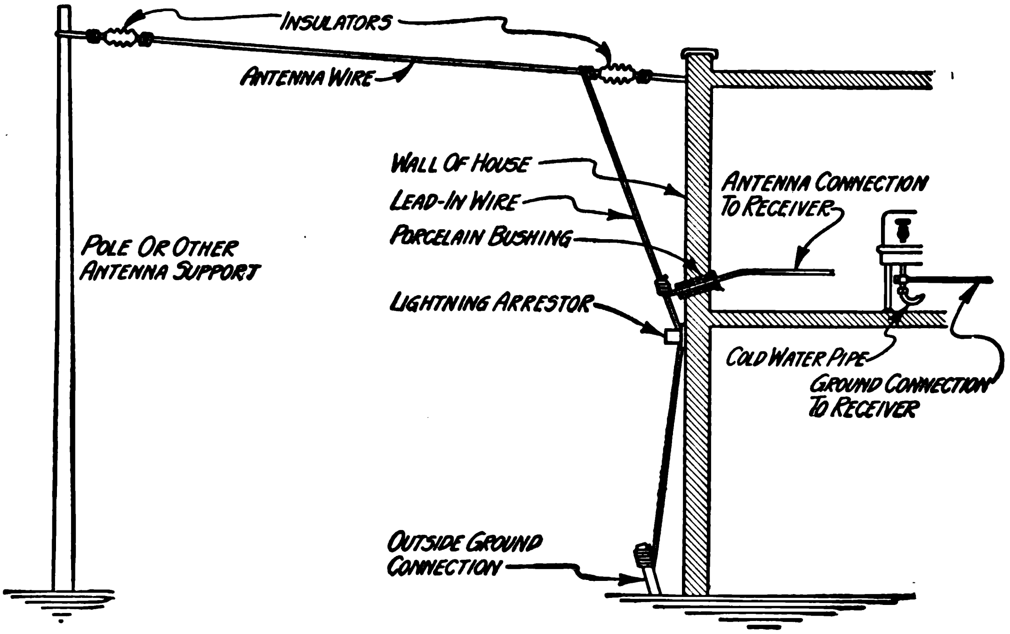
CHECK UP YOUR INSTALLATION WITH THIS DIAGRAM

FIGURE 1: *Pictured here are shown the rear view of the LC-26 Receiver, the cone loud-speaker, the filter unit, the three large "B" batteries, the small "B" battery, the charger, the charging switch and the storage battery. The connections between these units are shown in heavy lines to the exact binding posts and terminals that they should run to including the antenna and ground connections. If you use this simple diagram when installing your set you will find that it will give you perfect satisfaction.*

broadcast wavelengths. This circuit is similar to that used in the old variometer-tuned sets. What was a disadvantage in the old sets is, however, a great advantage in this receiver. The tuning of this particular circuit is extremely broad. This leaves the sharply-tuned trap circuit, which is the input to the detector, to do the actual sharp selecting that is necessary to tune out local stations and bring in the distant ones. Therefore, the receiver may be considered as essentially a single-control device (in the case of local reception) as the input tuning accomplished by the variometer has very little effect. It may be used as a sort of volume control. For distance, however, it helps considerably. The receiver cannot radiate on account of the use of the stage of non-oscillating radio-frequency amplification used ahead of the detector. Both circuits are controlled by the stabilizer (or intermediate circuit) which is coupled closely to the plate circuit of the radio-frequency tube and coupled looser to the detector circuit, thus allowing regeneration in the detector but preventing oscillation in the radio-frequency stage. This is a much more simple method than the usual compensating condenser or neutralizing scheme, as it is almost impossible to properly neutralize a single stage radio-frequency amplifier throughout the whole wavelength band when used with a regenerative detector.

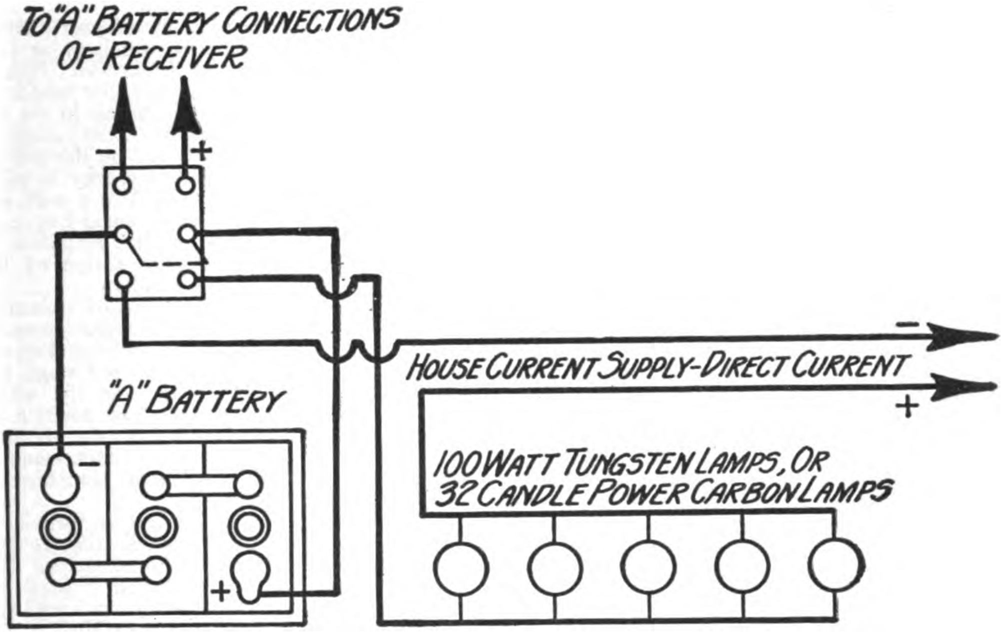
The audio-frequency amplification has been the subject of much experiment and has been chosen for its straight-line-frequency amplification and particularly at the low frequencies, so that the drum and bass viol tones are brought out with startling clarity.

If the receiver is installed and operated as described in this article it will bring to the experimental listeners a new thrill from broadcasting that comes from reception of this broadcasting as it is really being transmitted.



AN EXCELLENT ANTENNA ARRANGEMENT

FIGURE 2: *The design of the antenna is necessarily governed, in most cases, by the roof or yard space available. However, many of the ideas suggested by this illustration may be used to advantage in any antenna installation. The best length for the antenna will depend in each case on the interference conditions.*


To "A" Battery Connections Of Receiver
−
+
House Current Supply-Direct Current
−
+
"A" Battery
−
+
100 Watt Tungsten Lamps, Or 32 Candle Power Carbon Lamps

CONNECTIONS FOR CHARGING "A" BATTERY FROM DC HOUSE SUPPLY

Figure 3: *The type of battery charger used depends on the kind of house supply current. If it is alternating current, a regular AC charger is used. If the house supply is direct current, however, a simple arrangement of electric lamps is used as shown here. If preferred a DC battery charging resistance may be used instead of the lamps.*

The Theory of Operation

The antenna circuit of the LC-26 receiver is tuned to resonance with the incoming signal from a broadcasting station by means of the variometer A. (See diagram, pages 496-7 of the December issue of Popular Radio.) The fixed condenser G simply serves to adapt the receiver to the size of antenna used. This method of tuning the antenna circuit is probably the most efficient known because of the preponderance of inductance obtained in the circuit in this way.

It will be noted that the variometer is also in the grid or input circuit of the radio-frequency amplifier tube. Thus the variometer serves not only to tune the antenna but only as an autotransformer to transfer the antenna energy to the radio-frequency amplifier, the voltage drop across the variometer being impressed across the grid-filament circuit of the tube.

For a small amount of energy impressed upon the grid of a vacuum tube a comparatively large amount of energy may be made to flow in the plate circuit of the tube, due to the amplifying action of the tube. This additional energy is not generated in the tube itself but is drawn from the high-voltage "B" battery which is connected in the plate circuit of the tube. In other words, the energy in the output circuit of the tube is drawn from the "B" battery but the amount drawn is regulated by the throttle action of the grid circuit of the tube.

The energy in the plate circuit of the radio-frequency amplifier tube Q1 flows through the coil B which is in series with the plate and "B" battery. Coil C is closely coupled to this coil B, so closely that it absorbs much of the energy from the plate circuit of the first tube, thus preventing oscillation in the radio-frequency amplifier. Coil C with its tuning condenser E therefore serves as an absorption circuit or stabilizer. The fact that the first tube cannot oscillate prevents the receiver from radiating energy into the antenna system, a condition which would cause annoyance to neighboring receivers.

The energy absorbed by the stabilizer circuit is not lost, however, as this circuit is in series with the coil D and its tuning condenser F. Both of these coils are in the grid circuit of the detector tube Q2; therefore the energy absorbed from coil B is usefully transferred to the input of the second tube. In this circuit there is again a preponderance of inductance, consisting of the inductance of coil C plus that of coil B. The use of so much inductance is made possible by the fact that the two tuning condensers E and F are connected in series; therefore their total capacity is only half that of either one alone. Inasmuch as the frequency or wavelength of the circuit is governed by the product of the capacity and inductance, it naturally follows that the use of such small capacity calls for the use of large inductance. The stabilizer is tuned to a lower wavelength than the total grid circuit. This use of a double condenser is not therefore the same as that of tuning two stages of radio simultaneously. In this case it is a regeneration control. The energy input to the detector tube is not only amplified by this tube, but it is rectified. Up to this point in the circuit all the energy has been in the form of alternating current of high frequency. The output of the detector tube, however, consists of pulsating direct current which really amounts to direct current with an alternating current component. Both kinds of current are therefore present in the plate circuit of this tube.

The audio-frequency component of this energy is lead through the primary of the audio-frequency amplifying transformer J, but the radio-frequency current passes with difficulty through the high inductance such as that of this primary winding. Moreover, this radio-frequency component serves no useful purpose in the audio-frequency amplifier. It could be used to advantage, however, if fed back to the input side of the detector tube because then it would be amplified again by the amplifier action of the tube. This is exactly what is done. A wire is connected from the plate of the detector tube back to the coil C in the detector input circuit. This produces the regenerative action and results in the detector tube practically serving the purpose of two tubes, one use being a radio-frequency amplifier and the other use a detector.

Regeneration can only be obtained up to certain limits, of course. Carried beyond certain limits, the detector tube would break into oscillation, thus distorting the signals. In most regenerative receivers this is the practical limit to which regeneration may be carried. In the LC-26 receiver, however, it can be carried far beyond this point because oscillation will stop when the radio-frequency circuit is tuned to resonance with the input circuit to the detector tube, as is the case when both circuits are tuned to a broadcasting station's wavelength, and signals will be heard clearly and undistorted.

This explains why this receiver with its five tubes gives the results of a six-tube receiver, without any of the trouble usually encountered in neutralizing such a receiver.

For ordinary reception it is not necessary to have the detector oscillating. For long distance work, however, an oscillating condition of the detector tube makes the tuning of the receiver extremely simple, because it is merely necessary to turn the large tuning dial until a carrier wave whistle is heard, then adjust the variometer knob until, when it reaches resonance with the detector circuit, oscillation will suddenly stop and the distant station will be heard. The amount of regenerative action desired can be obtained by adjustment of the detector rheostat, P. The pulsating direct-current output of the detector is audible if a pair of headphones is connected in the circuit. From this point on in the circuit another type of amplification is used. The purpose of the radio-frequency amplifier was to build up the alternating current (radio-frequency) energy, thus increasing the sensitivity of the receiver. The purpose of the audio-frequency amplification used after the detector is to build up volume so as to make possible the use of a loudspeaker.

The energy flowing through the primary of the audio transformer J sets up a corresponding flow in the secondary winding of this transformer by the process of electromagnetic induction. The use of inductive coupling, as furnished by the transformer, is necessary here to isolate the grid of the audio-amplifier tube from the high voltage of the "B" battery in the detector plate circuit. By means of the secondary winding the energy is impressed on the grid of the tube Q3 and the amplified energy is taken out at the plate of this tube. The use of one stage of transformer-coupled, audio-frequency amplification produces high amplification (through the voltage step-up action of the transformer) of excellent quality.

The LC-26 receiver makes use of resistance coupling in the second and third audio-frequency amplifier stages. This type of coupling does not produce such great amplification per stage, but the reproduction is flawless over the whole range of audible frequencies. In addition to this, the current consumption from the "B" batteries is much lower with resistance-coupled amplification than with "unbiased" transformer-coupled amplification.

There is no particular point in providing variable adjustment of filament heating voltage for any of the tubes except the detector. For this reason the automatic filament control resistances O1 O2, O3 and O4 are used with the other tubes, and a rheostat is provided on the panel only for control of detector filament current.

The Antenna and the Ground

The antenna requirements of the LC-26 receiver are not at all critical and for that reason satisfactory results may be obtained with the use of almost any kind of a wire strung up wherever it is convenient.

As an example of just how great the sensitivity of this set is, plenty of volume is obtained from all the New York City and nearby stations when operating the receiver in the suburbs of the city approximately twelve miles from the nearest station, without using any antenna at all, by simply connecting the ground lead to the antenna binding post on the receiver, with the ground binding post left disconnected.

It is, however, in general use advisable to employ some sort of an antenna. As a matter of fact, where an outdoor and also an indoor antenna can conveniently be erected, it is worthwhile to put up both. This is suggested because during the summertime, when the static is troublesome, the indoor antenna can be used, thus eliminating much of this form of interference. During the cooler months when there is better reception weather, the outdoor antenna may be used. (Incidentally, this suggestion applies not only to this receiver but to all receivers which are sufficiently sensitive to operate satisfactorily on an indoor antenna.)

The outdoor antenna has the advantage of greater "pick-up" and is therefore to be preferred when it is desired to tune in distant stations. An outdoor antenna consisting of a single copper wire somewhere between 60 and 100 feet, is amply large for this receiver. Little is to be gained by making the antenna longer than 100 feet, but it is not advisable to have it less than 60 feet or thereabouts because of the decreased "pick-up." These lengths include

A Tuning Chart to Adjust to Your Own Set

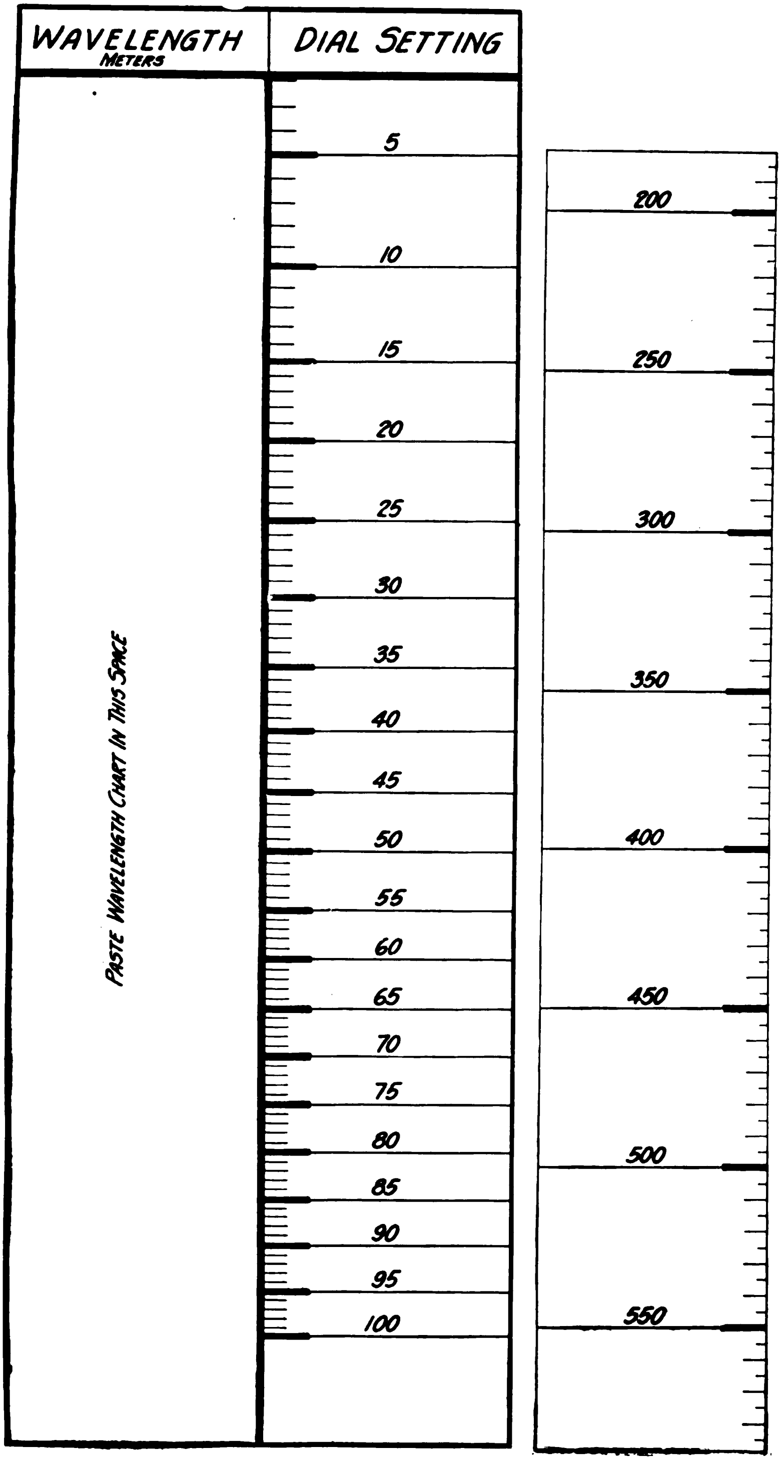


FIGURE 4:

Cut out the chart at the left and paste it on a piece of thin stiff white bristol paper. Then cut out the small chart at the right. It should be pasted in position on the blank space on the left-hand side of the main chart underneath the heading "wavelength" as shown in the December issue on page 504. To get it in exactly the right position tune in a station of around 350 to 400 meters and find out what setting it comes in on on your dial. For instance, a station on 405 meters would come in somewhere near 46, 47 or 48 on your dial according to the variation of the condenser in the set. If it comes in at 47, say, paste the wavelength part of the chart in place so that 405 meters on the wavelength scale is exactly opposite 47 on the dial setting scale. Then all the other stations will tune in exactly as indicated by the completed chart.

the entire length of the wire, from the antenna binding post on the receiver to the end most distant from the receiver.

It is impossible to give exact instructions for erecting an outdoor antenna because practically every installation has its own peculiar conditions and requirements. However, in Figure 2 is illustrated an ideal antenna. Some of the ideas suggested in this illustration may be used in all installations. The matter of insulation of the antenna and "lead in," for instance, may be used in almost every case. Some general suggestions for this may be offered: For instance, it is not advisable to have the antenna wire close to trees or buildings, but especially trees. A distance of ten feet should be the minimum spacing from the latter obstacles. If necessary to use a tree to support the further end of the wire, be sure that the insulator is placed at least ten feet from the foliage. In such a case precautions must be taken to prevent the wire from being broken by the swaying of the tree in the wind. This is most easily accomplished by running the wire through a pulley fastened to the tree and suspending a weight on the free end of the wire, making ample allowance for the free play of the wire.

The kind of wire used is not particularly important so long as the wire is copper. It may be plain wire not smaller than No. 14. Or it may be the regular seven-strand aerial wire. Make the antenna proper and the lead-in all one piece if this is possible. If this cannot be done solder the joint where they come together, thus insuring a good electrical connection.

The height of the antenna is important only up to a certain point. It is, of course, well to make it as high as conditions will permit. Put it as high as you can, but try to get it higher than surrounding objects if that is possible. If the antenna is erected on the roof of an apartment house which is already occupied by a number of other antennas, try to put it above and at a right angle to the others and see that it is clear of the pent houses and vent pipes. If it is necessary to erect poles on the roof, don't be satisfied to tie the poles to vent pipes; drill a hole part way through a heavy wood block, set the block on the roof (it need not be fastened down), erect the pole with its base resting in the hole in the block and then guy the pole with at least three wires. The other ends of the guy wires may be secured to bolts in the walls, or to the bases of other vent pipes. Galvanized iron guy wire of about No. 12 size is good for this use because of its strength.

A good ground connection is also important. If the house is provided with a cold water supply, the ground wire may be fastened to the water pipe nearest the receiver by means of a ground clamp. Hot water pipes will also serve in a pinch, but do not ground the receiver to a gas pipe: this is against the rules of both the gas companies and of the Board of Fire Underwriters, and in addition is usually a poor ground because of the insulating gaskets frequently installed in the pipe line where it enters the house.

The Batteries

A 6-volt storage "A" battery is required for lighting the filaments of the vacuum tubes and for the high voltage plate supply a set of "B" batteries of 157½ volts is used.

The "A" battery should be one of not less than 100-ampere-hour capacity and should, of course, be one designed for radio use. When the receiver is in operation the current drain on this battery is approximately 2¼ amperes-per-hour and a fully charged 100-ampere-hour battery will operate the receiver for about forty hours without recharging. Batteries with greater capacity will, of course, operate the receiver a longer time on a single charge.

A hydrometer should be used to measure the state of charge of the battery. This instrument measures the specific gravity of the electrolyte in the battery and is equipped with a scale which reads from 1,150 for a discharged battery to 1,300 when the battery is fully charged. The battery should never be allowed to run down to such an extent that the reading falls below 1,185. Many make a practice of recharging the battery when the reading falls to 1,200, and this is a good practice.

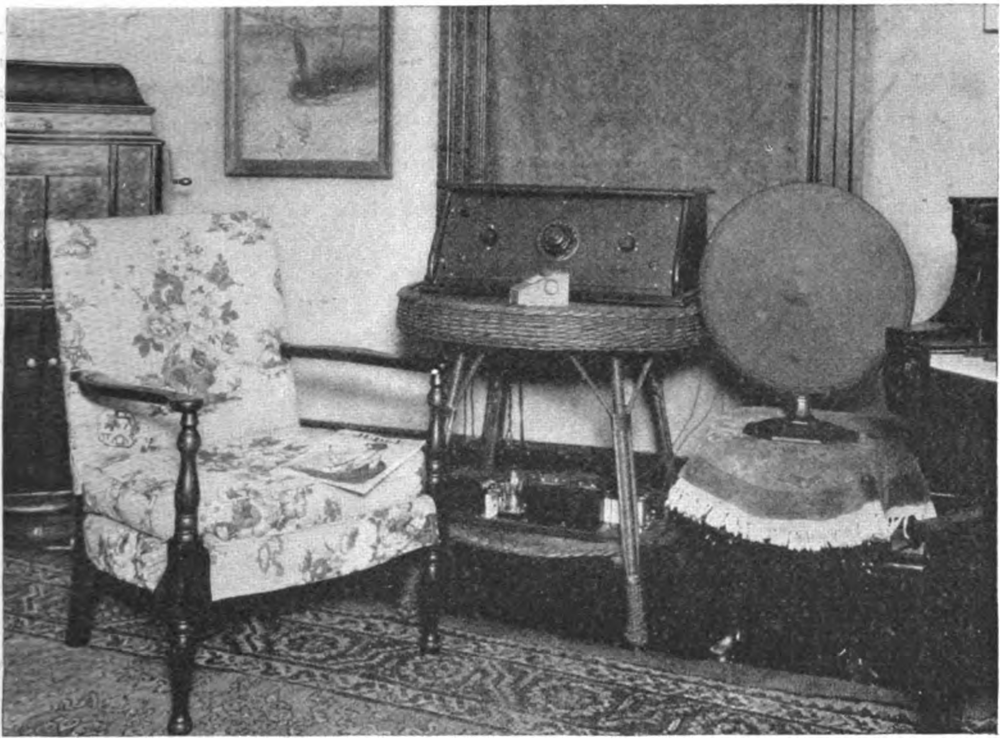
The "B" battery consumption of the LC-26 receiver is lower than that of most five-tube receivers, in spite of the fact that the voltage used is somewhat higher than usual. In ordinary use the dry-cell type of "B" batteries is therefore entirely practicable. Using the full voltage specified above and with the receiver operating an average of two hours a day, a set of the ordinary large size "B" batteries will have a life of between five and six months.

Using the "heavy duty" type of batteries the life will be increased to approximately ten months under the same conditions. The life

Hours of use daily	2	3	4
Large size batteries	166 days	105 days	72 days
Heavy duty batteries	297 days	190 days	134 days

THE LIFE OF THE BATTERIES

This table shows the approximate life of a set of "B" batteries with the LC-26 *receiver. It will be noted that the "heavy duty" type of batteries give almost double the service of the usual "large" (five pound) type, although the cost of them is only about 50 percent greater. The above figures are based on the use of the total voltage specified (namely, 157½ volts), but takes into consideration the normal drop in voltage as the batteries wear down. When the batteries drop from 45 volts each to 34 volts they are worn out and should be replaced.*



From a photograph made for Popular Radio

THE LC-26 INSTALLED WITH THE RAYTHEON PLATE-SUPPLY UNIT

Figure 5: *This picture shows the receiver working without "B" batteries. The Raytheon unit as described in the November issue of* Popular Radio *may be seen on the shelf of the table with the cone loudspeaker at the right.*

of these two types of batteries under various conditions are shown in the table on page 16 The use of the "heavy duty" type of batteries is recommended where dry-cell batteries are used because their increased life is greater than their increase in cost over the usual "large" size batteries; they are therefore cheaper in the end.

If the receiver is to be used on an average of more than two hours a day the use of storage "B" batteries is recommended. The first cost of such battery equipment is considerably higher than that of dry cells, of course, but the first cost is about the only cost for perhaps several years, as the cost of recharging the batteries is so small as to be insignificant.

In place of "B" batteries the Raytheon Plate Supply Unit (described in the November issue) may be used with results equal to those obtained with either the dry-cell or storage "B" batteries. This unit has several advantages. There is nothing to wear out and require replacement, as in the case of dry-cell "B" batteries, and recharging is not required as in the case of storage "B" batteries. In addition, this unit takes up less room than do batteries of either type and the first cost is no greater than that of the storage type of "B" batteries.

In using the Raytheon unit with this receiver, the total output voltage of the unit is applied to both the radio and audio-frequency amplifier tubes of the receiver. The connections are shown in Figure 1. Using such high voltage on the radio-frequency amplifier tubes would not prove satisfactory with most receivers because of the tendency of this portion of the circuit to oscillate. In the case of the LC-26 receiver, however, the radio-frequency stage will not oscillate, regardless of the voltage applied. The detector "B" + post on the receiver is connected to the post on the Raytheon Unit bearing the same designation. The knob of the variable resistance in the Raytheon Unit is then adjusted to a position where signal strength is greatest. This will provide the detector tube with the proper plate voltage. The position of the knob will be almost all the way out.

An "A" battery charger to operate from the electric house lighting line will be needed unless the owner wishes to go to the trouble of taking his storage battery to a service station to be charged. Some manufacturers are placing units on the market which consist of a storage "A" battery and charger combined to operate from the alternating current house line and which operate automatically so that no attention is required other than the occasional addition of distilled water to make up for evaporation. There are also several types of alternating current chargers on the market. When the charger and battery are separate, a five-ampere charger is recommended, and the particular type selected will depend on the purchaser's judgment. The three main considerations in the case of a charger to operate on AC are constancy of operation, noiselessness and necessity for replacement of parts. The first two points may be determined by requesting a demonstration before purchasing. In general the type of chargers using a rectifier tube are to be preferred as they require no adjustment, are foolproof and most nearly noiseless.

When storage "B" batteries are used, some means must be provided for charging them.

"A" battery chargers may be obtained which will also charge the "B" batteries, or attachments may be purchased to use in conjunction with "A" battery chargers when it is desired to charge the "B" batteries. Then, of course, separate "B" battery chargers are on the market and at comparatively low cost.

In Figure 1 will be found a convenient method for connecting up the "A" battery charger in such a way that it is only necessary to throw the switches to put the battery on charge.

When the house-lighting supply is direct current, only a charging resistance is needed. This may be a bank of five 100-watt lamps connected in parallel as shown in Figure 3.

The Tubes to Use

The UV-200 or C-300 tube has been found best for the detector tube in this receiver. The extreme sensitiveness of this receiver is due largely to the employment of regeneration in the detector circuit and this circuit has been designed with the UV-200 type of tube in mind. Other tubes will not provide the same sensitiveness, nor as good tone quality.

For the radio-frequency amplifier a UV-201-a type of tube is used, as also in the first and second stages of audio-frequency amplification. That is, the first, third and fourth sockets from the left-hand end of the receiver, the detector socket being the second.

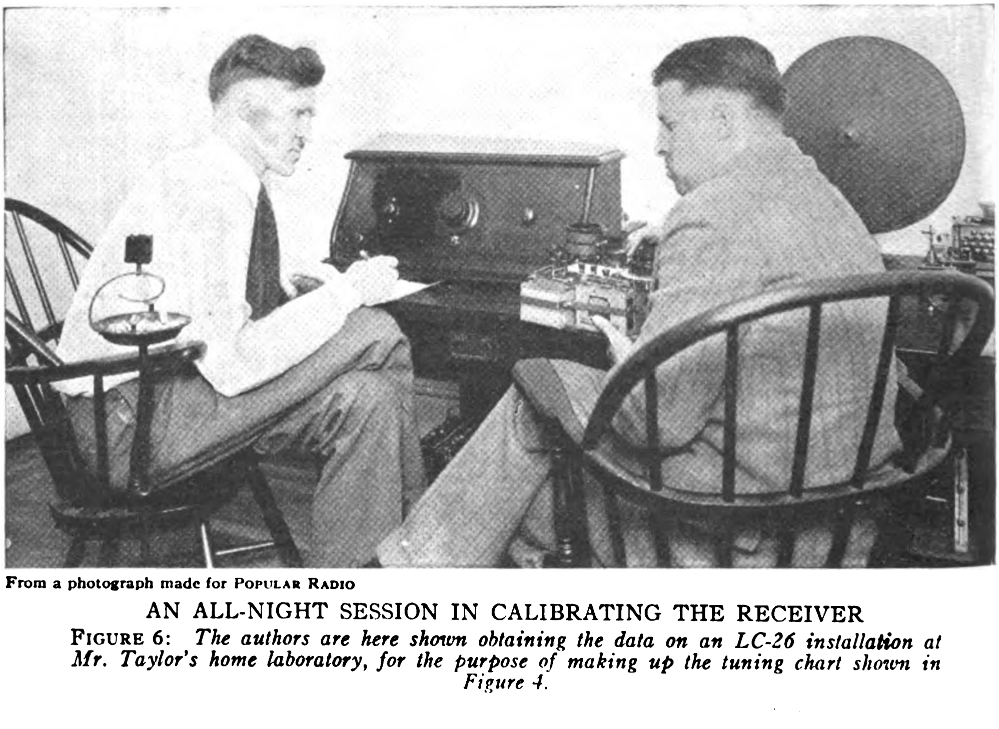
In the last socket, which is in the third stage of audio-frequency amplification a power tube is used because the usual types of tubes such as the UV-201-a cannot handle the great volume in this stage. The set is designed to use a Radio Corporation UX-112 power tube in the last stage with a No. 112 amperite to control the filament current. A UV-201-a tube can be used but will not produce the maximum in tone quality or volume but if it is used an amperite cartridge of suitable resistance must be used with it. Builders of this receiver who happen to have a Western Electric VT-2 or 216-A tube on hand can use it in this last stage. In that case a No. 1 amperite should be used.

The use of UV-199, WD-12 or any other of the dry cell tubes in this circuit is not advised.

The Operation of the Receiver

The connections to antenna, ground and batteries are clearly shown in Figure 1.

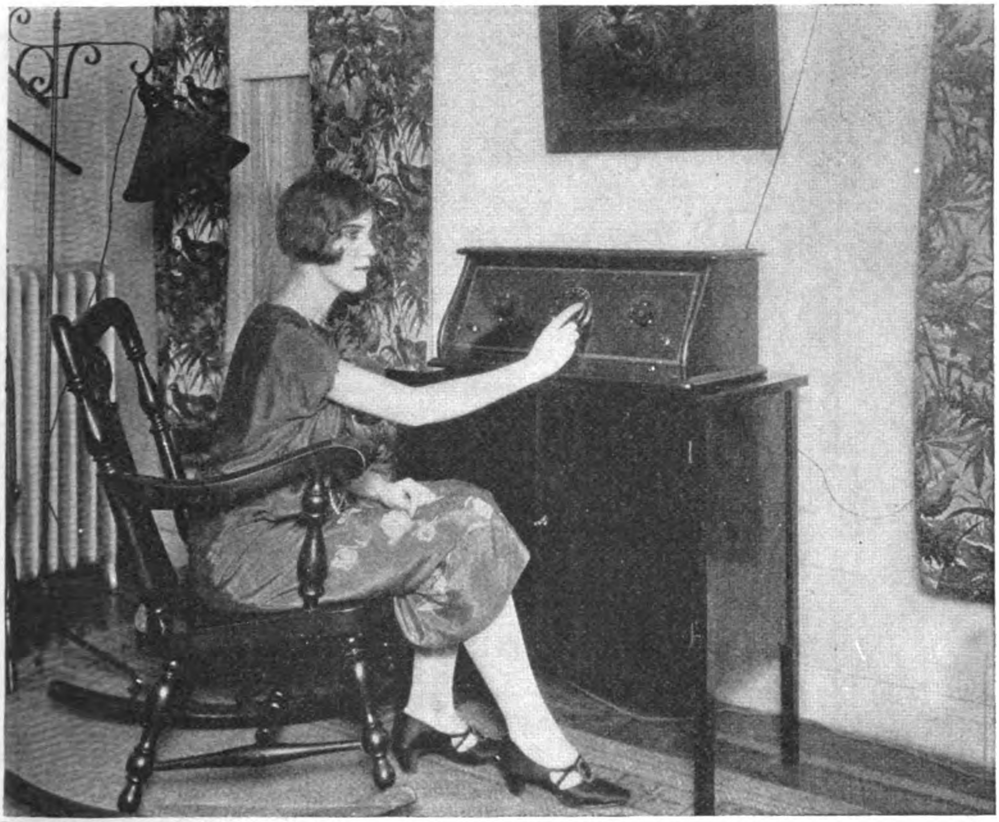
Before making these connections, place the five vacuum tubes in their respective sockets. Starting with the first socket at the left, the tubes to be used are: UV-201-a, UV-200, UV-201-a, UV-201-a and UX-112. Now connect the



From a photograph made for POPULAR RADIO

AN ALL-NIGHT SESSION IN CALIBRATING THE RECEIVER

FIGURE 6: *The authors are here shown obtaining the data on an LC-26 installation at Mr. Taylor's home laboratory, for the purpose of making up the tuning chart shown in Figure 4.*



From a photograph made for POPULAR RADIO

AN LC-26 INSTALLATION WITH DRY CELL "B" BATTERIES AND A STORAGE "A" BATTERY

FIGURE 7: *An ideal installation of the receiver, with the batteries placed in a radio cabinet. The wire shown running from the upper right-hand corner of the set along up the wall is an extension cord to the cone loudspeaker which is placed on the other side of the room.*

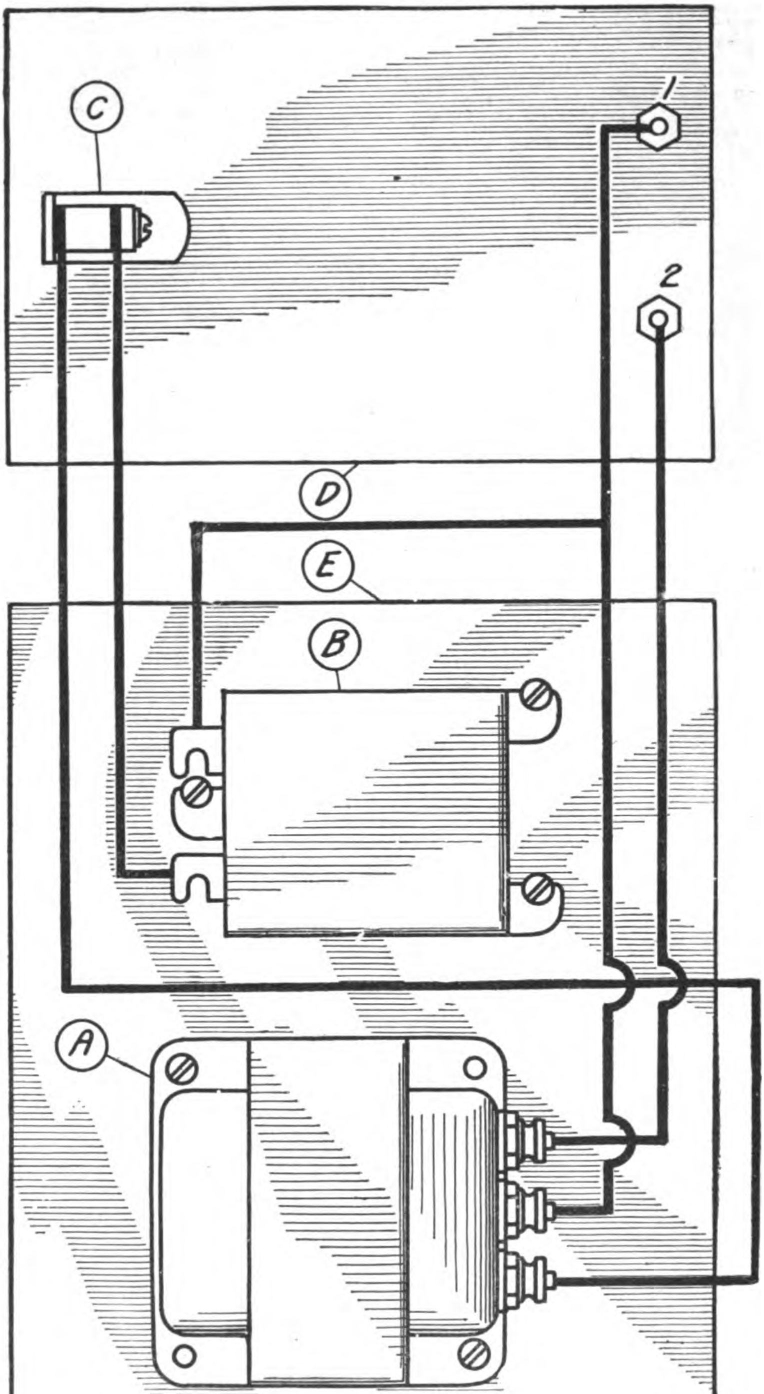
"A" battery with its negative side to binding post No. 3 and its positive side to binding post No. 4. To be sure that the filament circuits are all intact, turn the battery switch on the front of the receiver to the "on" position. All but the second tube should light up. Next turn the small right-hand knob half way on, in a clockwise direcion. This should light the detector-tube filament.

If all of the tubes light up properly, remove all but the first and connect the "B" batteries as shown in Figure 1. The four tubes should be removed first to avoid the possibility of burning them out in case anything goes wrong in the wiring which might permit the "B" battery voltage to be applied to the filaments. In such a case the single tube left in the set would light up very bright. If everything is right up to this point, connect the antenna and ground to the receiver, replace the other four tubes, and insert the loudspeaker plug in the jack S.

Signals from a broadcasting station can now be tuned in. The tuning dial should be set for the station desired, the proper setting being obtained from the tuning chart in Figure 4. Next rotate the small left-hand knob until the station is heard with maximum volume. The switch R1 should be turned to the left for an outdoor antenna and to the right for the indoor antenna. As explained before, the purpose of this switch is to adapt the antenna circuit constants to the antenna in use.

Now that a station is tuned in, try different settings of the detector rheostat (the small right-hand knob on the panel front). One point will be found at which signals have the desired strength and clarity. This is the proper setting. The point of maximum reception, however, will not be the same on nearby stations, as on distant stations, the latter requiring that the rheostat knob be turned further in a clockwise direction. Do not tune in stations with more volume than is enjoyable.

After tuning in several local stations, and becoming somewhat familiar with the operation of the receiver, try a more distant station. Set the large dial for the station you wish to tune in, then slowly rotate the left-hand knob until the station is picked up. When the station is heard, adjust the tuning dial and the two



A REVISED DIAGRAM OF THE SHUNT-PLATE FEED UNIT

FIGURE 8: *This is used to keep the direct current of the plate supply out of the loudspeaker, allowing only the alternating current of audible frequencies to pass through the loudspeaker.*

small knobs until suitable volume is obtained. Now the proper adjustment for the grid-leak I may be made.

With the distant signals tuned in rotate the knob of I until the signals are at the maximum. It is best to move this knob a little at a time, and to remove your hand from the receiver while the effect of the change is being noted, otherwise the presence of the hand on the grid-leak may have a slight detuning effect. The proper setting of the grid-leak will usually be found to be with the knob screwed a little to the right of the point where a clicking or rattling sound is heard as the knob is rotated. Once the proper setting of this instrument has been found it may be left indefinitely at that setting.

The last stunt to be tried is to change the three UV-201-a tubes around until the best position for each is found. One of the three may be found to function better than the other two as a radio-frequency amplifier tube (in the left-hand socket). Leave the tubes in the sockets in which the combination is found to be best.

It is extremely easy to tune in distant stations if the heterodyne beat method is used. This is accomplished by turning the rheostat knob far enough in a clockwise direction to cause a hissing sound in the loudspeaker, indicating that the detector circuit is in an oscillating condition. The tuning dial is then rotated until the whistle of a carrier wave is heard. Leaving the tuning dial set at this point the left-hand small knob may be rotated until the whistle suddenly stops and at this point the speech of music from the station will be heard, somewhat distorted. The distortion can be cleared up by turning the rheostat knob back (anti-clockwise). The tuning dial and the two small knobs should then be slightly readjusted to bring the station up to maximum volume. When looking for distant low-wave stations, keep the left-hand small knob turned with the arrow in a horizontal position and pointing to the left. For high-wave stations the left-hand small knob may be turned further in a clockwise direction. With a few minutes practice one can become proficient in this method of tuning.

When this method of tuning is used with the loudspeaker connected to the set the whistle of the carrier waves will, of course, be audible to listeners who may be in the room with it.

Do not be afraid of using this method as the receiver cannot radiate. So far as interference with neighboring receivers is concerned, there need be no worry; even when using the heterodyne method of tuning the first tube does not oscillate, therefore the whistles are confined to the detector circuit and do not get to the antenna where they might cause trouble to the neighbors who have receivers.

To turn off the receiver it is only necessary to throw the switch R2 to the off position. This breaks the "A" battery circuit and automatically turns off the "B" batteries. If the "Raytheon Plate Supply Unit" is used instead of "B" batteries, it will also be necessary to withdraw the plug in the line which supplies the house-lighting current to the Raytheon unit.

Installation and Equipment

For the assistance of those who are contemplating the installation of an *LC-26* receiver, brief descriptions of the installations in the homes of three of the members of the POPULAR RADIO organization are given below, with illustrations.

In all three cases the cone-type of loudspeaker is used. In one of the illustrations the loudspeaker does not show, as it is suspended in a doorway between two rooms with the object of keeping it as far from walls and other obstacles as possible, thus eliminating a certain amount of harshness which is present when any loudspeaker is so placed that emitted sounds of large volume strike a flat, unbroken surface such as that of a bare wall, at close range.

In two of the illustrations it will be noted that the receivers are placed close to the window where the antenna lead-in wire is brought into the house. This aids the general efficiency of the antenna. The ground leads in each case are kept as short as practicable also.

The diagrams given of these three installations will show some differences in the current supply for the receivers. In the photo and diagram, Figure 5, for instance, the high-voltage plate supply is obtained from the Raytheon Plate Supply Unit, which may be seen on the shelf under the table. A constructional description of this unit was given in the November issue. The filament supply in this case is obtained from a six-volt storage battery. In Figure 7 the plate supply is from regular dry-cell type of "B" batteries. The filaments are supplied by a combination storage "A" battery and charger (Gould Uni-Power).

In Figure 6 storage "B" batteries are used to provide the plate supply. A glimpse of these may be had on the shelf under the table. The filaments are supplied by a six-volt storage battery installed with a charger and switching arrangement so that in order to charge the battery it is only necessary to throw the switch to the "charge" side.

In the case of Figure 8 there is one piece of equipment used which does not show in the picture but is found helpful in producing the utmost in tone quality; it is a shunt-plate unit connected between the loudspeaker and the set, the purpose of which is to keep the direct current from the batteries out of the loudspeaker windings, where it serves no useful purpose, but to permit the full modulated current of the signals to pass through the windings. In addition to improving the tone, this device prevents any demagnetizing effect the direct-current flow might have on the magnets of the loudspeaker. This unit is somewhat similar to that described on page 556 of the December issue. Slight changes in the connections as shown there were made in adapting it to the LC-26 receiver, however. The diagram of the filter, as used with the *LC-26* receiver, is shown below in Figure 8.

We are glad to give definite assurance that this receiver cannot, under any condition, radiate energy into the antenna circuit. It is truly a "golden rule" receiver.

"RADIO MAY METROPOLITANIZE THE RURAL DISTRICTS"

That radio is destined to have a marked effect upon two widely different types of newspapers—the large metropolitan dailies on one hand and the small town newspapers on the other—is the conclusion of the author of this article. He is the publisher of LE PETIT PARISIEN, *and one of the best-known journalists of France.*

Will Radio Kill the Small Newspapers?

By SENATOR PAUL DUPUY

A LARGE group of newspaper owners, publishers and editors have decided that radio is a serious menace to the newspaper world.

Similar antagonism has been caused by former innovations. When the first phonographs appeared, theatrical people forecast the death of opera and concerts. They were wrong; the phonographs helped musical productions. The first movies were denounced as an agent that would destroy the legitimate drama. Yet today the stage thrives as never before and the prosperity of the cinema is proverbial.

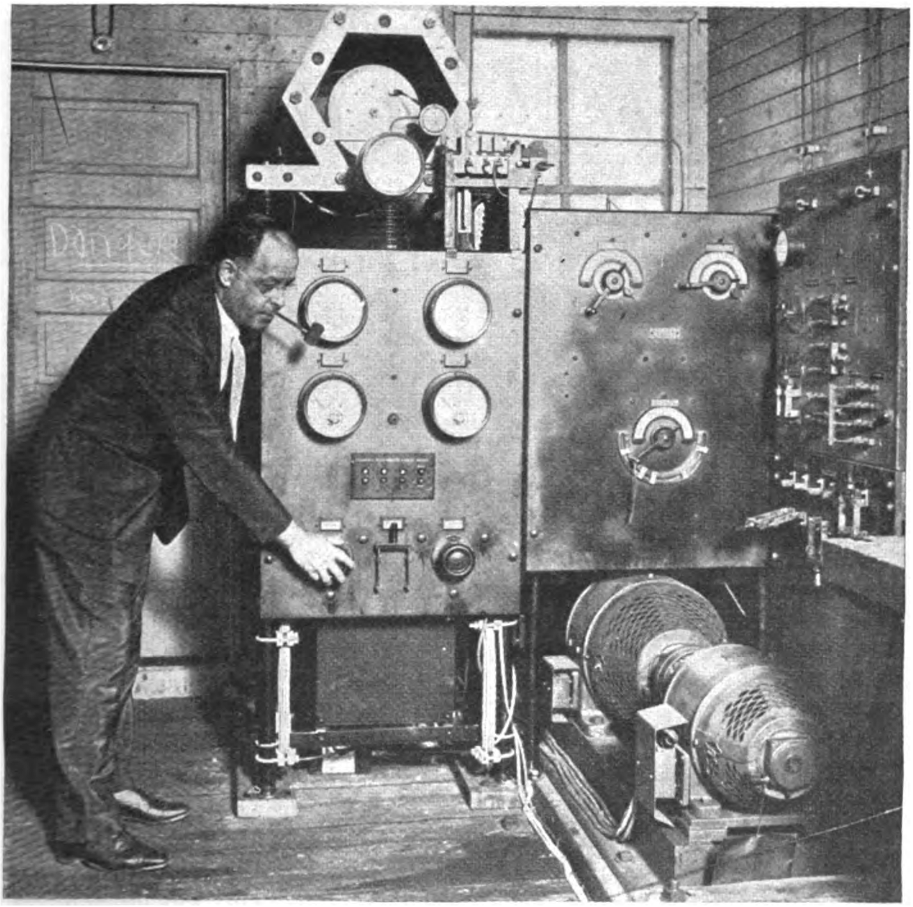
Now it is radio's turn to receive the attention of the gloom dispensers. Just as labor has objected to each new mechanical device, so the stage, the screen, the press are wailing over the "ruin" to be visited upon them by radio. Yet theater managers who have had the nerve to broadcast plays or parts of plays report that the broadcasts increased the box office receipts. And certainly there have been no reports of bankruptcy or of loss of circulation from those newspapers that have erected broadcasting stations even though they put upon the air some of the same news that later appears in their columns.

There is one possibility that may be regarded as a danger. By the use of radio we may eventually metropolitanize the rural districts and smaller towns. Their interests may become identical with the interests of the big communities. This possibly will menace the life of the country newspaper.

It may be that the rural resident will, eventually, prefer to read the suburban edition of the big daily, as he will there get a wider scope of information about the events of which he heard by radio the night before.

But even this may prove less a matter of regret than we should at first think. After all, the individual is rapidly sinking into unimportance, and the community or the state is becoming the unit of human thought. As the world shrinks, as it is made smaller by rapid means of communication, by ships, trains, airplanes, telephones, telegraph and radio, the nation may also gradually become secondary and the world will be one great unit, recognized as such not only by the statesmen and the diplomats but also by the man in the street.

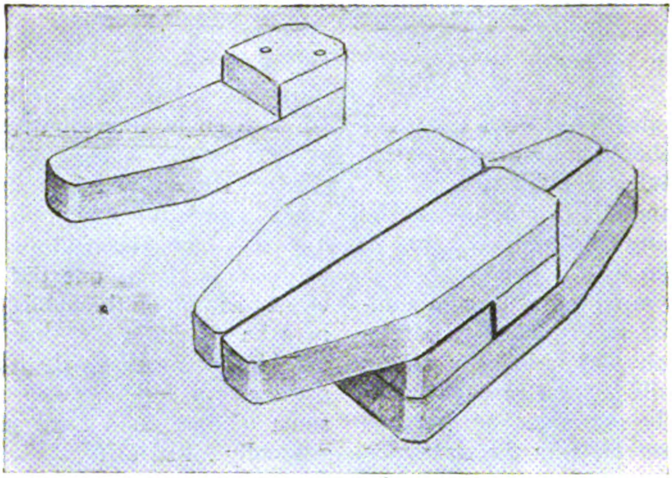
In that day the little local paper will be of such slight interest that it will die a natural death, unmourned even by its owner. Radio will have been more directly responsible for this change than any one other element of our complex civilization. It is one possibility of the effect of radio on the publisher. The time may be coming when, because of radio, the big metropolitan dailies will have a greater rural influence and, as a corollary, some of the small local papers will be gradually killed off.



Pacific & Atlantic

THE NEW UNDER-WATER TRANSMITTER

To enable the crews of submarines to converse with each other while their vessels are submerged, the Navy Department has developed this special apparatus.



HOW NATURE ARRANGES MOLECULES

FIGURE 1: *This wooden model illustrates the common pattern in which molecules are arranged. Each atom resembles a wooden shoe; four shoes closely packed form a unit of structure that is repeated again and again.*

The ATOM

ARTICLE NO. 4

The Nature of Crystals

Tremendous power is believed to lie within the minute and constantly moving particles of matter known as atoms. The entire universe, the scientists tell us, is made up of only ninety different kinds of atoms. One of these—the thorium atom—furnishes the activating power for modern vacuum-tube filaments as used in modern radio transmission and reception; this is one instance in which the energy that lies within the atom has been harnessed. To extract the energy from atoms and to make it of service to civilization is one of the most important problems that now comes before the experimenters in science.

By SIR WILLIAM BRAGG, K.B.E., D.Sc., F.R.S., M.R.I.

WE have seen that when the effects of heat motion sufficiently overpower the forces of mutual attraction between the molecules, the latter may have an independent existence and form a gas; and, further, that when the forces have gained somewhat the upper hand the molecules may cling together and still retain a considerable freedom of motion; the substance is then a liquid.

We have now to consider a final stage in which the molecules are so locked together that no molecule can move from its position. It is, let us say, tied to the next molecule at more than one point, so that the whole structure is rigid or solid; fastened together as the various parts of a bridge are riveted together in a firm whole.

The persistent tendency to form a crystal is very mysterious. Given time enough, Nature will always succeed in arranging the molecules according to a pattern, and, in general, a very simple pattern (Figure 1). The molecules may lie for a time in a higgledy-piggledy way, tied together so strongly that the substance behaves more or less like a solid; this is the case in glass. But the molecules are always trying to creep into their places in a regular scheme, and often succeed in time.

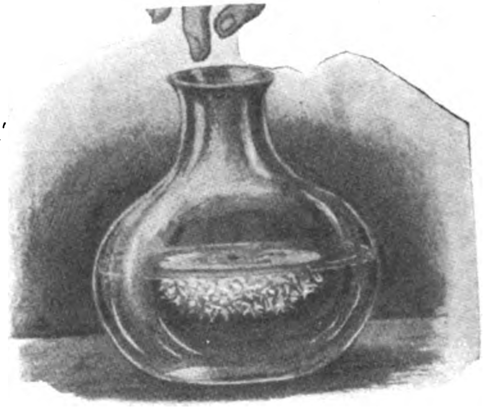
Is every solid body a crystal therefore? The answer to the question is that it tries to be, and is in general far more successful than usually appears. Some things are obviously crystalline, such as quartz or, as it is sometimes called, rock crystal. *Krustallos* is the Greek for both quartz and ice. Other substances are less obviously of crystal form. Such are the metals which usually show no regularity of outer form, but do so under certain circumstances; in all cases, the crystalline structure can be proved by the use of X-rays. And again, there are many cases where X-rays alone can show the crystalline structure which otherwise would be overlooked, as, for example, in a film of paraffin wax melted on to a plate.

One or two experimental illustrations of the process of crystallization may be given. An old and well-known example is shown in Figure 2. The sodium acetate which is dissolved in the liquid is very ready to crystallize; all the molecules are ready to set to partners and are only waiting for someone to begin. A little encouragement is given by dropping in a minute crystal of the substance, which sets an example to the rest, and the crystals are seen to grow quickly until the whole mass is really solid. Or, again, we spread a very saturated solution of a substance on a glass sheet in the lantern; the heat dries off the liquid and the crystals grow quickly under our eyes. This substance crystallizes easily and quickly, and for that reason gives us a convenient and ready illustration. Other things take long to form; the diamond, for example, takes so long or requires such special arrangements that the mode of its growth is very imperfectly understood.

A crystal is a regular arrangement of the units of pattern; just as an orchard may contain a regular arrangement of trees. The plan of an orchard may, of course, be drawn on a piece of paper, while the plan of a crystal could only be fully set out in space of three dimensions, but the analogy is sufficient. Our object is to find out the plan. When we stand in a regular planted orchard or hop-field, we see rows of trees and alleys between them running away from us in many directions. In a crystal there are lines of the pattern units running away in all directions from any one of them; and, further, many planes can be drawn through any one of these lines, each of which will be studded with the units in regular fashion.

Now, if we were told that in a certain orchard there were alleys 12 feet wide that ran in a north and south direction, and other alleys of other widths that ran in other directions, we should have enough knowledge to enable us to make a plan of the orchard showing the positions of the trees. In the same way, if we could find the distances between a few different sets of planes of the crystal, we could map out the positions in space of the units that lie on these planes.

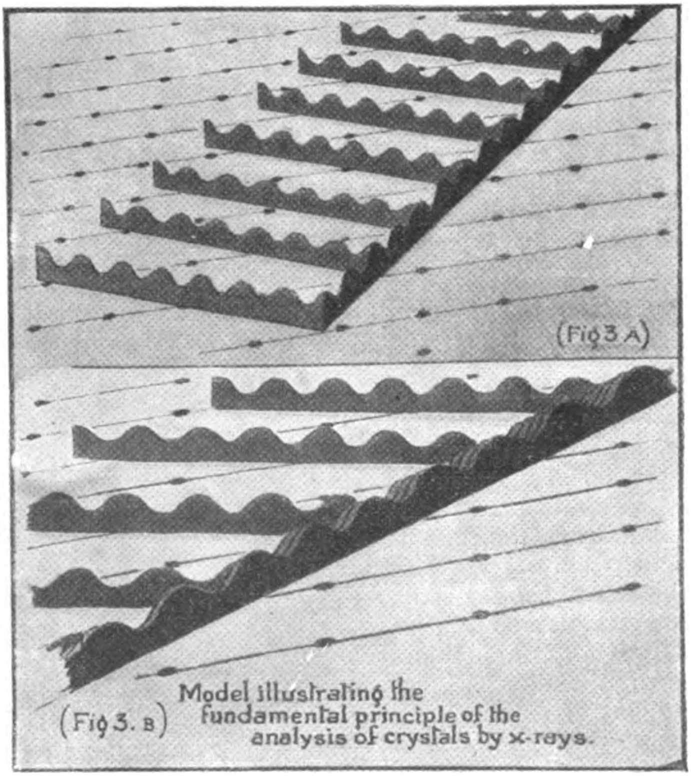
This is exactly what the X-rays enable us to do; they give us the



A SIMPLE ILLUSTRATION OF CRYSTALLIZATION

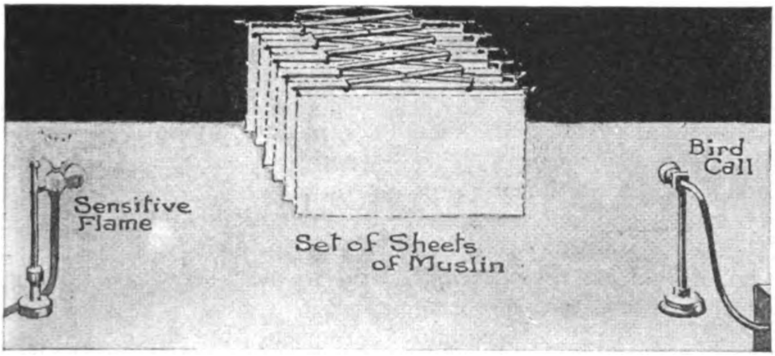
Figure 2: *The sodium acetate in the decanter is more than ready to crystallize. But the process does not begin until a minute fragment of the crystal itself is dropped into the solution.*

distances between the various sets of planes. The mode in which the measurement is made is somewhat difficult to understand without some knowledge of the physics of wave motions; but perhaps the model shown in Figures 3a and 3b will be of some assistance. The model consists, in the first place, of a table on which spots are painted at regular distances; they represent the arrangement of the pattern units in the crystal. Stencils made of thin sheet lead are cut to represent waves. On the left of the picture the waves are supposed to be rolling in on the crystal, and the stencils are, of course, arranged to be in step with each other. The successive sheets which can be drawn through the pattern units in the crystal act like reflectors, each sheet reflecting a very feeble wave, while the great bulk of the wave flows on and meets successive sheets. The model is intended to show some of these reflected waves passing together out of the crystal on the right. It may be seen from the model that these bundles of reflected waves may or may not be in step with each other as in Figures 3a and 3b respectively. In the former case, there is a comparatively strong reflected wave formed by the combination of the weak reflected waves, of which there may be hundreds of thousands. In the latter the waves are out of step; and there is practically no wave motion as the result. It all depends on the relative adjustment of three factors—the length of the wave, the distance between the successive sheets, and the inclination of the direction of the advancing waves


(Fig 3 A)
(Fig 3. B)
Model illustrating the fundamental principle of the analysis of crystals by x-rays.

HOW CRYSTALS ARE ANALYZED BY X-RAYS

FIGURES 3A AND 3B: *By means of these two models the fundamental principles of this phenomenon are illustrated as explained on pages 25 and 26.*



HOW SOUND IS REFLECTED

FIGURE 4: *Lord Rayleigh's experiment, to demonstrate the phenomenon of the reflection of sound, by means of a set of sheets of muslin; an illustration of the reflection of x-rays by a crystal.*

to the planes of the sheet. In practice, what happens is that the crystal is slowly turned round while bathed in a beam of X-rays; at certain angles the reflections flash out. From the magnitude of the angles the distances between the sheets are calculated.

Many years ago the late Lord Rayleigh showed an analogous experiment of acoustics. A high-pitched whistle (Figure 4) emitted sound-waves one or two inches long. A set of muslin sheets was held by a "lazy-tongs" arrangement so that their distances apart could be varied; the sound went through all the sheets, losing a little of its intensity by reflection at each of them. The combined reflections acted upon a sensitive flame, making it flare as shown; but only if the distances between the sheets were properly adjusted.

The experiment of the X-ray and the crystal is the fundamental experiment of the new investigations into the structure of matter. It shows how the pattern units are spaced in the crystal.

The diamond is perhaps the most interesting of all the crystals in the world. It is remarkable for the beauty and simplicity of its structure, and important because it is the simplest of the forms in which the atoms of carbon join themselves together. The basis of structure of organic substances can be found within it. It is the hardest mineral that we know, and its brilliance makes it one of the most prized of all jewels. It is already possible to explain many of the properties of the diamond from a consideration of the way in which Nature has designed it. Every carbon atom has four neighbors placed round it in a perfectly symmetrical manner. This is in perfect agreement with the long-established chemical fact that the carbon atom tends always to link itself with four other atoms and no more. For example, methene is a gas in which the molecule consists of a carbon atom linked to four hydrogen atoms. This is the marsh gas which is generated in marshy ground, and sometimes burns with a feeble light, the so-called will-of-the-wisp.

It is odd that the simple form in which carbon atoms group themselves should make so brilliant a gem, and that a form nearly as simple should be so opposite in character as graphite or black lead. A single crystal of graphite is almost unobtainable and the X-ray methods are somewhat hampered in their application to the determination of its structure.

It is impossible to reduce it to powder in a mortar. It becomes simply a mass of fine flakes which slide over one another with the utmost ease. For the same reason, it is easy to slip on a black-leaded hearthstone, because some of the flakes cling to the hearthstone and some to the soles of one's shoes and the flakes slide readily over one another. Graphite therefore makes one of the best of lubricants.

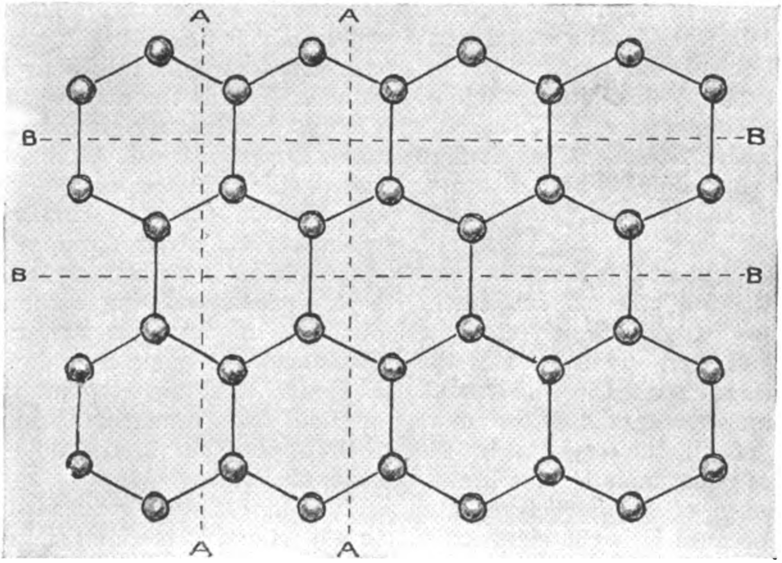
The diamond and graphite structures are the only two which are composed of carbon alone. Structures of carbon and hydrogen, or carbon, oxygen and hydrogen, or the same with a flavoring of other atoms, are very numerous and form a most important part of the substances found in nature. Indeed, their study constitutes the bulk of the subject of organic chemistry. They are found as the main constituents of living organisms, whence their name; we meet them continually in industrial work, as in the dye industry, the leather industry, the cotton industry, the manufacture of explosives, and in many other places, so that their study is of the highest importance.

If we dissect the diamond structure, we arrive at combinations of carbon atoms which we find are the basis of all these organic compounds. We take the graphite sheet which we have formed by splitting the diamond in parallel planes; it is a hexagonal network. We now cut through certain bonds and divide the whole up into separate hexagons. Each carbon atom is now joined to two others; it has two idle bonds. To one of these we attach in each case a hydrogen atom, and we have now the famous benzene ring.

Benzene was discovered by Faraday in 1825; a few drops of his original liquid are preserved in the library of the Royal Institution. He did not know its form, only that six carbon and six hydrogen atoms went to the making of it. It was Kekulé who first guessed that the carbon atoms formed a closed chain.

The benzene ring is found in half of the sum-total of organic substances, and because some of the first to be studied were the essences of the lemons, oranges, and the like, the whole class of substances founded on the benzene ring has been called the "aromatic."

The placing of the hydrogen atoms



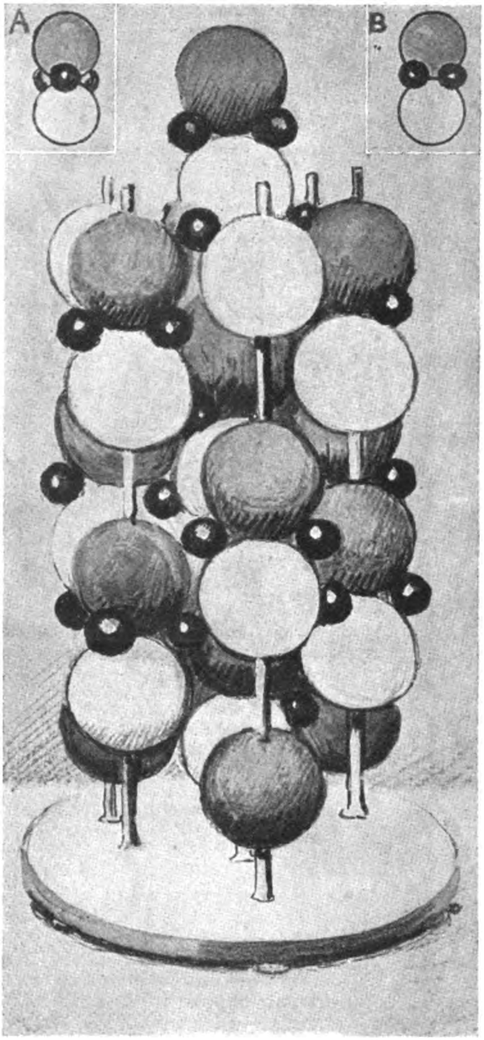
THE HEXAGONAL FRAMEWORK OF THE DIAMOND

FIGURE 5: *The graphite sheet that shows the division into the two kinds of chain molecules,* AA *and* BB.

round the benzene ring has quite removed the strong attachment to other rings which it had when it formed part of the graphite sheet. Benzene is a liquid at ordinary temperature. All sorts of additions and substitutions can be made to the ring, and every new substance made in this way has its own special properties.

The graphite sheet may be cut up in other ways: along the lines *a a* in Figure 5, or, again, along the lines *b b*. The chain may be of infinite length. Both these chains occur in Nature; they are the basis of the so-called chain compounds. They have been investigated in the Royal Institution. Dr. Muller and Dr. Shearer have found it possible to measure the length of the chain to a high degree of accuracy. Take for instance, the latter chain; every carbon has vacancies for two attachments except the end carbons, which have three. Let one of them be satisfied with three hydrogens, and let the other end carry a special group formed of two oxygens and one hydrogen. Then we have a series of substances called the "fatty acids," all known to chemists and named by them. Thus we have palmitic, myristic, lauric acid, and others. When the chain is short, the substance is liquid at ordinary temperature. But the longer chains belong to solid substances, and the longer the chain the higher the melting point.

When a little of one of the solid members of the series is melted and poured on to a piece of glass or mica, layers of molecules are formed on which all the molecules are perpendicular to the glass; and the layers lie above one another, hundreds in succession, like a series of carpets, each hair of which represents a molecule. It is the arrangement in layers which makes it possible to measure the lengths of the molecules by means of X-rays.



THE RUBY MOLECULE

Figure 6: *This model contains two atoms of aluminum and three of oxygen. A shows one side of a molecule and B the other side.*

Important Kinks in Wiring

What wires to "bunch"; what wires to isolate; what wires to use spaghetti covering on—these are some of the useful bits of information in an article by Louis W. Hatry—in Popular Radio *for February.*

From a photograph made for POPULAR RADIO

A PRACTICAL INVESTIGATOR OF COILS AND THEIR FUNCTIONS

The author of this article, who is an instructor in radio, is an Associate Member of the American Institute of Electrical Engineers and of the Institute of Radio Engineers. His studies of coils have helped materially in the work of radio experimenters.

SOME NEW AND USEFUL FACTS ABOUT

COILS

Many fallacies exist in the minds of experimenters about the "low-loss" feature of coils or inductances. Many of the so-called "low-loss" coils that are now popular in the radio field have lower efficiency than some of the older types. Just what constitutes a "low-loss" coil and how the characteristics of coils have been carefully studied is told in this article.

By D. R. CLEMONS

DISTRIBUTED capacity of inductance coils may be defined as the inherent constant C_0 which satisfies the equation for frequency,

$$f = \frac{1}{2\pi\sqrt{LC_0}}$$

for the coil free and oscillating at its fundamental, and for the coil operating in a tuned circuit, C_0 satisfies the equation

$$f = \frac{1}{2\pi\sqrt{L(C+C_0)}}$$

in which C represents condenser capacity lumped in farads, L the pure self induction and C_0 the distributed capacity of the coil, units being in farads and henrys.

As both the self induction and distributed capacity of coils follow directly the geometrical dimensions of the coil, in obtaining a maximum self induction with a given length of wire, a large capacity may result. Inherent coil capacity, which is undesirable, involves the coil dimensions and the inductive capacity of the dielectric through which the electric field acts, hence with a given self induction the variable is the constant K, of the medium surrounding the coil. The most satisfactory formulas for evaluating coil capacity seem to have been given by Mr. G. Breit, and for cylindrical windings of bare wire in air, with the coil free and ungrounded, C_0 yields well to the formula

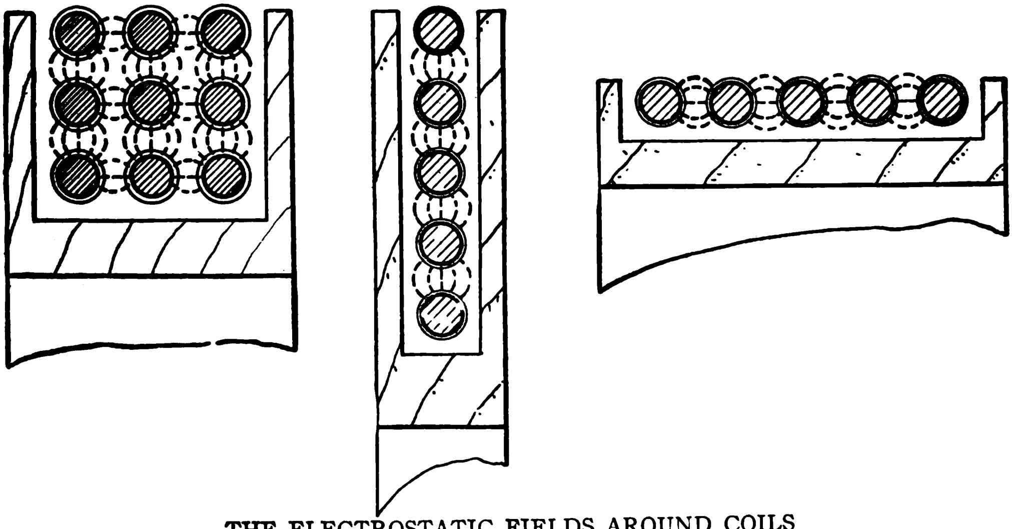
$$C_0 = 0.06952\, K\, l \text{ m-mfds.}$$

where l is the coil perimeter and K the inductivity of the dielectric. The constant K is usually doubtful, as dielectrics about coils are largely influenced by compound materials such as insulation, tubing, and possibly varnishes.

Interesting discussions have arisen due to divergent opinions as to the exact effect of foreign dielectrics such as varnishes which tend to increase undesirable capacity inherent to the coil. One prominent writer believes that "due to the higher constant of insulating papers, the addition of papers between layers (of multi-layer coils) will increase the distributed capacity directly as the inductive constant of the paper."

From the literature dealing with losses in inductor coils it seems that with capacity a certain fault in coils, any addition whatever of varnish or insulation which tends to increase capacity magnifies the defect directly as the constant of such added material. As a result of snap judgment one visualizes enormous increase of capacity and this has led to an over-estimation of its magnitude. While application of varnishes does increase the coil capacity, it is impossible in any coil for this increase to be directly as the inductive constant of the varnish used, and in most cases is entirely removed from the constant. In fifteen coils successively treated with various high class varnishes, every one showed an actual decrease of effective resistance. This was due to the better insulating properties of varnish than for raw cotton and silk insulation *exposed to atmospheric changes of humidity.* To show the actual improvement of the various coils, Table I is given. Not one showed an increase of resistance after having been treated.

It will be shown that capacity increases directly as the inductive constant only when the coil's electric field is entirely



THE ELECTROSTATIC FIELDS AROUND COILS

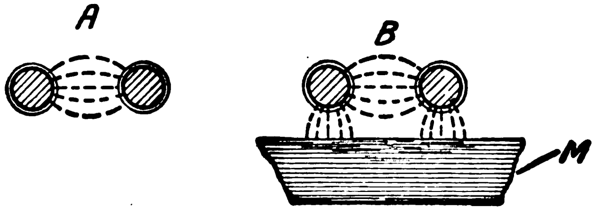
FIGURE 1: *At the left is shown a multi-layer coil with its accompanying electrostatic field; notice that it covers a greater area than the fields in either the spiral winding (in the center), or the solenoid winding (at the right). The wires are shown as in cross-section.*

occupied by the added dielectric material which condition is never possible in fact; also, other factors which indirectly determine capacity increases include, or depend upon the coil shape, nature of wire insulation, penetrability and inductivity of the varnish or compound and so on.

Characteristic electric fields are shown for the solenoid, spiral and compact windings, which embrace practically all types of winding now in use, sketches being given in Figure 1. While greatest flux density is found between adjacent turns for the spiral and cylindrical windings, the density per unit area is much greater in the compact windings due to the components of the many turns in traverse layers acting through small distances. By observing the induction effects between two circular areas one may form a mental picture of the action in the entire field as applied to coils of any shape.

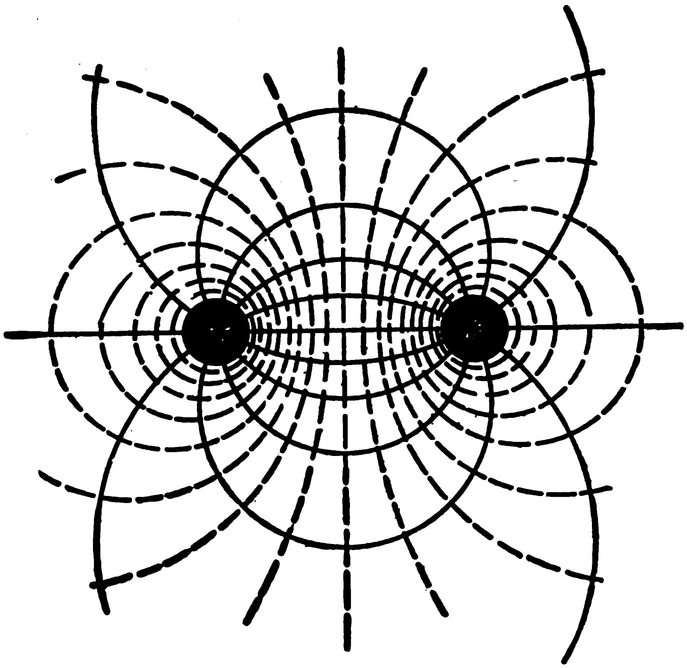
In Figure 2, two wire cross-sections represent two areas on adjacent turns of a winding, the wires having cotton insulation of normal thickness, the remaining medium being air. Now, the potential difference acting through space between the sections permits an atomic orientation or orbitary shifting of the tiny electrical components within atoms occupying space and the dielectric about the two surfaces, which motion is equivalent to a movement of electrical energy and is large or small according to the inductivity of the medium considered. The potential of one section acting toward the potential of the second section at very high frequencies causes such action in the medium, and we may consider it a sudden and highly transient movement of electrical energy through the medium. We may think of the intensity of this movement as closely resembling the quotient of the strain divided by the stress as in mechanics. While displacement is present, energy is stored in the medium, and as displaced units can act through but a short distance they have a velocity and distance, which gives the equivalent of current for a short interval of time; so for high radio frequencies the period of the potentials appearing on the wire sections becomes more nearly equal to the free displacement period of the entire atomic system of the dielectric, at which frequencies the energy stored during transient periods is considerable.

To represent this action in space where it becomes necessary to observe the equi-potential lines along which induction is taking place, familiar lines of electric force may be obtained. Both the gradient distribution and apparent lines may be observed by laying two smooth metal discs on an ebonite plate; a potential of several thousand volts is applied to the electrodes and fine mica dust is sifted over the space occupied by the electrical fields. The dust particles arrange themselves as the solid lines shown in Figure 3. We find that such electric lines of force represent only lines along which induction and displacement act, that they arise and return perpendicularly from potential surfaces, and that



THE ELECTROSTATIC FIELD BETWEEN TWO TURNS OF WIRE

FIGURE 2: *At A is shown the distribution of the electrostatic field between two turns of wire in air and at B is shown the field of two turns of wire wound on an insulating tube. Notice that in this case the electrostatic field is included through part of the insulating material thus slightly increasing the capacity between the two turns of wire.*



A THEORETICAL FIELD OF FORCE BETWEEN TWO TURNS OF WIRE

FIGURE 3: *Two black dots represent the two wires in cross-section and the dotted lines are the equi-potential lines. The solid lines show the apparent lines of force that have been given roughly for different types of coils in Figure 1.*

a number of them from one electrified surface is related to more than one other surface, or between numbers of other surfaces acting in the same medium in the case of inductance coils. Where a large number of turns are acting in a small volume of space the distribution of potential causes displacement quite uniform near each surface, but in acting through the dielectric, the entire displaced action is formed by the component of the many points acting as in Figure 4. Methods for calculation of component fields represented by such lines were given by Maxwell and others.

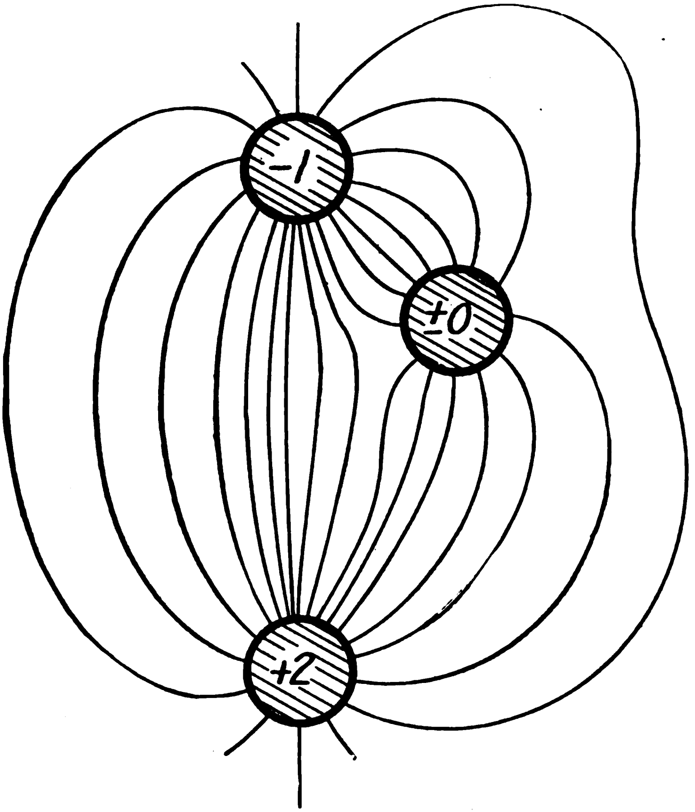
Referring to Figure 6D (assuming a uniform dielectric everywhere about the wire surfaces) the capacity is increased according to the constant of the medium, and the flux in the medium at any region is the voltage gradient of that segment divided by the flux resistance or elasticity of the medium in that segment, which latter value is the reciprocal of the permittance in the dielectric segment considered. And were the two wires without insulation other than air, we have a uniform flux distribution in space as considered from the current axis at any instant; hence under these conditions the coil capacity yields well to formula calculations of distributed capacity for the air insulated coil in free space.

Now; let us suppose that these two wires are sections wound on a fiber tube, M, or are near to some medium of higher permittance than air as shown in Figure 2B.

We find that, due to the higher permittance of the medium at M, a high gradient and approximately equal displacement is also present in M in addition to that through the air or between the two wires, assuming that both wires are separated from the tubing M and from each other only by their cotton insulation. Obviously, then, we have in addition to the flux actually between turns, another growth of flux through the medium M, and the capacity is accordingly increased by the presence of this new sub-material. Though induction acts through a much greater distance in the medium M than for the space directly between the wires, it occurs through a medium of considerable permittivity, and if this is sufficiently high the voltage division permits considerable flux to be developed.

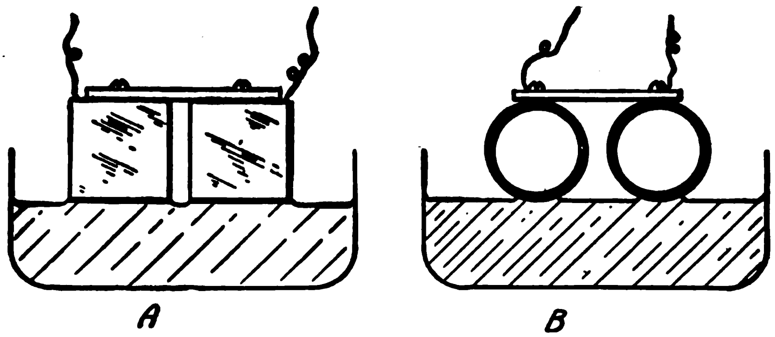
To demonstrate the reappearance of flux in greater density even though acting through such greater distances, the following experiments were made:

Two hardwood cubes 1.25 inch on a side were covered with lead foil glued to their surfaces; the blocks were secured by screws to a bakelite strip, their separation being about 0.1 inch between parallel surfaces. Short terminals of very fine wire connected with the blocks are shown in Figure 5A. Now, one familiar with condensers considers the surfaces or area actually between the two plates, since the edge effect is negligible as compared with flux density in the dielectrics of high inductivity generally used. Between electrified bodies having plane surfaces, displacement may act through a medium not actually between the parallel surfaces forming the electrodes. This "edge effect" between plates as computed by Maxwell is demonstrated at Figure 7. The two blocks suspended in air gave 26.1 m-mfds. capacity. The blocks were lowered to touch the surface of a quantity of olive oil and then raised to prevent cohesion and capillarity, the oil being shown in Figure 5A, for



THE DISPLACEMENT OF ELECTRIC LINES OF FORCE IN CROWDED COILS

FIGURE 4: *This drawing shows diagrammatically how the electric fields between adjacent turns in multi-layer coils may be crowded and distorted. Although the spacing at the surface of the wire is usually fairly uniform, the spacing in the less densed part of the field is usually non-uniform.*

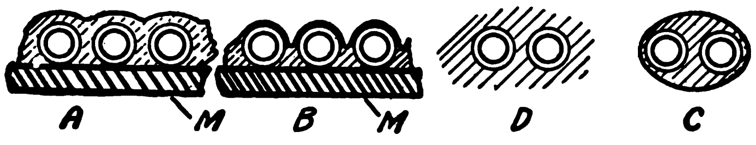


HOW THE TESTS WERE MADE

FIGURE 5: *These drawings show how two square fiber blocks and two cylinders covered with foil were used in tests in a tank containing oil to determine the effect of change in capacity when the blocks and cylinders were suspended in air or when they touch the surface of the oil which had a higher dielectric constant than air itself.*

which position the capacity became 36.8 m-mfds. The increase of 40 percent is due to the effects previously explained and shown in Figure 2B. To represent the effect for round wires, two fiber cylinders 1.25 inch diameter and 1 inch long were covered by a cylinder of foil and adjacent surfaces were separated 0.06 inch as shown in Figure 5B. In air the capacity between these cylinders was 1.70 m-mfds., and when lowered to oil, the surfaces barely touching the surface as shown, the capacity increased 53 percent to 2.61 m-mfds. Obviously the potential redistributes itself in acting through this new medium. At this time the cubes were entirely submerged in the oil which extended a depth of 0.5 inch on all sides of the blocks. The capacity increased from 26.1 for the blocks in air to 66.5 m-mfds., giving an increase of 2.55, which compares well with the inductivity of the oil, which was 3.08. This illustrates experimentally that the presence of new dielectrics about wires should increase the distributed capacity of the system. The increase is slight and never becomes according to the constant of the material unless the entire electric field acts in the new medium. The blocks did not show an increase according to the constant K for this reason, but submerged to a greater depth in a greater volume of oil, the constant was approximately the same as the ratio of the capacities for the two positions. Figure 2B is equivalent to wire wound on insulating material.

To show the actual increase of capacity due to forms and tubing requires exacting methods. The tubing must be removed without any disturbance whatever of the coil dimensions. To draw a tube from a coil without changing dimensions of the coil, hence its self inductance, is almost impossible; hence, simply to measure the fundamentals of a coil with and without the tubing does not indicate whether it is capacitive, inductive, or a change of both constants. When meas-



HOW TESTS WERE MADE ON COILS WITH WIRE COVERED WITH AN INSULATING VARNISH OR FILLER

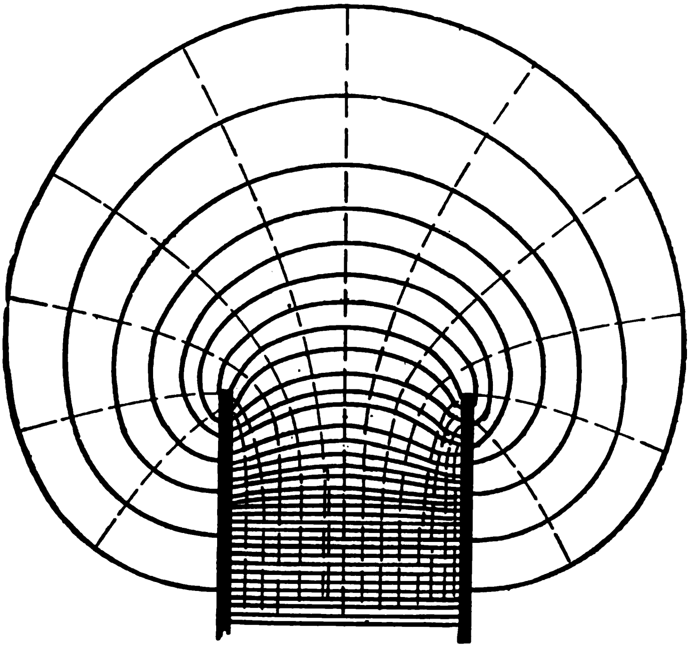
FIGURE 6: *At the left are shown wires wound on an insulating cylinder and then varnished or dipped in an insulating compound. Notice that the compound makes a body that covers up the wires in greater or less degree.*

ured in terms of wavelength only, the effects of tubing on coil capacity are reported much too large and lead to an over-estimation of this effect.

To show exactly the increase to expect from the addition of tubing the following experiments were performed:

A flint glass cylinder 0.08 inch thick and having a slight taper was obtained and wound with No. 26 double-cotton-covered wire into a coil 18.5 cms. long and 7.0 cms. mean diameter; several thin strips of paper were pasted along the outer surface forming spirals to securely hold the winding shape constant during the experiment. The coil was carefully measured and found to be of 824.8 mhys. pure inductance and of 2.889 m-mfds. distributed capacity. Then the glass tube was carefully removed and the coil, now a mere shell, was measured and found to have 824.8 mhys. pure inductance as before but a smaller capacity of 2.580 m-mfds. When the tube was again inserted both constants were found to be again their first value, showing that while the inductance remained constant the tubing increased the capacity only 11.8 percent although the glass had a very high constant of 6.85. By sealing one end of the tube it was then filled with oil, giving in effect an oil core inside the winding, for which the capacity increased 2.68 times becoming 7.76 m-mfds.

Next, the tube was filled with distilled water. The capacity became 23.92 m-mfds., the inductance in both cases remaining the same (the constant of distilled water is about 80). The coil was then removed from the tube and dipped in hot paraffin which was absorbed by the insulation and enclosed the wires somewhat as shown in Figure 5 at A, its depth being about 0.6 inch. The capacity increased to 4.39 m-mfds., showing a tendency to increase according to the constant when the material occupies the space subject to maximum flux density along the winding.



THE FIELD AT THE EDGE OF CONDENSER PLATES

Figure 7: *The curve of the equi-potential lines and the stressed lines at the ends of two parallel condenser plates. Notice how the field is bent around the edges of the plates.*

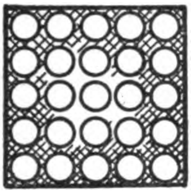


FIGURE 8: *This drawing shows how a multilayer coil impregnated with liquid varnish really has only the outer portion covered. The varnish seldom penetrates through the insulation except by long immersion.*

Owing to the difficulties encountered in removing bakelite tubing from the finished winding without altering the self induction of the coil, another method of measuring the effect of bakelite material was resorted to. We have elsewhere referred to the similarity of constants and field distribution about solenoids and spirals of small winding depth, and we find by observation one plane surface of a perfectly flat spiral is equivalent to the inner cylindrical surface of the solenoid; therefore, by laying a perfectly flat spiral upon a sheet of material we have the equivalent of a tube having the same thickness as the sheet, and the effect on the capacity is identical. In this way there is no change of self induction or of initial capacity while handling the coil. A flat spiral 17.4 cms. diameter wound with 41 turns of No. 22 double-cotton-covered wire having 220.2 mhys. inductance and 3.10 m-mfds. capacity for the free coil was first placed on a sheet of laminated bakelite material 10 inches square and 0.187 inch thick, the copper being separated from the material by its cotton insulation only. The capacity increased from 3.10 m-mfds. to 4.60 m-mfds., which is 1.48 times the free coil capacity; then, when lain on a similar grade of material twice as thick or 0.376 inch, the capacity became 5.6 m-mfds., which is 1.81 times its free value. Though this increase is considerable, it is not proportional to the constant of this very satisfactory material having inductivities of 2.6 to 3.07, depending on the grade.

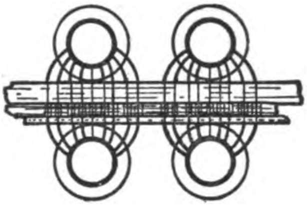


FIGURE 9: *This diagram shows the action of a few layers of paper on the electrostatic fields between layer turns of wire.*

To show the increase of capacity for a dielectric of greater volume and which is everywhere closely related to one surface of the coil, the spiral was next lowered with one surface resting on oil having a constant of 2.11; then the capacity, due to the action being illustrated in Figure 2B, was increased from 3.1 m-mfds. to 6.70 m-mfds., which is about as before, 1.821 times the free coil capacity. To provide a dielectric of high permittance distilled water was again used and the coil lowered to the surface gave 79.4 m-mfds. capacity which increased from the normal 3.1 m-mfd. Although the constant of distilled water is about 80 the increase is but 25.5 times the free coil capacity. The inductance was not altered by the presence of the water. Obviously, then, the addition of tubing will only slightly increase coil capacity; the increase will not be directly as the constant of the tube or form but is governed somewhat by it, also the thickness and nature of the material together with considerations of the insulation depth on the wire.

Insulating varnishes may be applied to solenoids and spirals without increasing their resistance at normal frequencies, nor does varnish or impregnations appreciably increase the capacity of the coil if it is applied thinly. Referring to Figure 6 at B we find that wires wound over the tube have a slight increase due to the tubing being inserted or remaining in the electric field; then since varnish seldom does more than penetrate the fibers of cotton and silk, and probably merely fills the cavities within the winding, a great quantity of material is not added by a light application of varnish though it occupies a position of greatest density about the wire. Hence the mere substitution of one dielectric for another does not cause a great increase of capacity.

For example:

A solenoid of 23 double-cotton-covered wire had a capacity of 7.245 m-mfd., and after having applied three heavy coats of Redmanol, a phenol product, the capacity increased to 8.275, which is but 14 percent above normal for this extra heavy application of this varnish, and though its constant is about 2.62 when properly dried under heat and pressure.

Although cotton and silk have each an inductivity of about 4.86 when it resembles a solid dielectric, it is not an important detail where the insulation about wires consists of cotton or silk as these are usually a complex non-solid nature due to the complex position of the fibers making up the dielectric; therefore, cotton insulation absorbing varnish becomes practically a compound solid dielectric. For solenoids and spirals, since varnish ordinarily occupies but a small part of the entire electric field the capacity increase in them is small and is certainly far from any direct relation to the constant of the varnish material, but with a given coil the increase will largely depend on the absorbing properties of the wire insulation together with *the amount of varnish applied* and its inductivity when dried.

In Figure 6A, where A represents a greater quantity of varnish than at B, the capacity at A should be larger than at B which is small, since at A the flux acts through a greater volume of dielectric material than at B where a large part of the field is through air only. To demonstrate this: two No. 22 double-cotton-covered wires having a length equal to one complete turn on the coil described were lain parallel and twisted together; their capacity was 22.80 m-mfd.; then the wire was submerged in olive oil as in Figure 5D for which the capacity became 69.0 m-mfd. for the oil dielectric; then, by drawing up the wires cohesion of the oil gave a distribution of oil as at Figure 5C, which is about the shape that applied and dried varnish would have assumed, then the lumped capacity was but 57.0 m-mfd. Therefore, a light application of varnish would resemble B and C in Figure 5 for which the capacity increased 2.25 times, while for complete submersion the increase is obviously 3.02, which was found to be the constant of the oil used. Such wetting of the winding gives the equivalent effect of an applied varnish on the coil. We have shown the coil capacity should increase according to the constant K only when the electric field is entirely contained within the added dielectric, but this is never the case for coils used in radio circuits and of the solenoid and spiral class, but since the field of the compact windings of square cross-section is largely contained within its winding surfaces, the field of the latter type does act almost entirely through impregnation material applied to coils of the *compact* type, and the increase is approximately as the constant. To illustrate this: 3 coils of equal wire-lengths were designed for best shapes in spiral, cylindrical and compact types of winding. By submerging each coil below the surface of oil of known constant we have the equivalent effect of the electric field acting within a large dielectric about the entire coil, while, by withdrawing them, the oil wetting the insulation and adhering between turns is at once equivalent to an application of varnish, which method applied to the three coils described gave the following results:

Coil	*Co Dry in Air, m-mfd.*	*Saturated, m-mfd.*	*Submerged, m-mfd.*	*Increase per cent.*
Solenoid......	3.566	4.18	4.44	17.3
Spiral.........	2.520	2.972	4.04	18.0
Compact......	4.190	7.547	8.684	80.0

For the first two the gain is but 17 and 18 percent of the free capacity, but for the compact winding the saturated ca-

TABLE I

Coil	*Wire-insulation*	*Kilocycles*	*Resistance without varnish*	*Coated with thin layer of varnish*	*Final resistance*	*Decrease percent.*
15	23 double cotton	1000	27.70	Shellac	23.65	—14.5
16	23 " "	1000	27.27	Redmanol	25.21	— 7.6
17	23 " "	1000	27.40	Collodion	25.10	— 8.4
18	23 " "	1000	27.66	Paraffin	24.68	—10.8
19	23 " "	1000	9.22	Redmanol	8.75	— 5.0
11	30 " "	500	68.00	Shellac	63.50	— 6.7 3 layer banked
7	23 " "	500	28.10	Shellac	24.30	—13.5 2 layer banked
8	23 " "	500	4.50	Collodion	4.26	— 5.2
9	26 enamel	200	28.40	Shellac	26.90	— 5.26
10	22 double silk	200	67.40	Bakelite	58.45	—13.3 rectangular channel
14	24 enamel	200	10.74	Shellac	10.14	- 5.6

pacity is 1.8 times the free capacity, while complete submersion increased the capacity 2.07 times, showing that the *compact* winding gives a capacity increase *nearly* as the inductive constant with perfect saturation or impregnation. The oil in this case had a constant of 2.11. Air pockets and impenetration prevented a direct increase, therefore, a coil of the honeycomb type of 100 turns was submerged. This permitted penetration to all parts of the coil and the increase was from 11.27 to 23.61 m-mfd. which is approximately as the constant 2.11 of the dielectric.

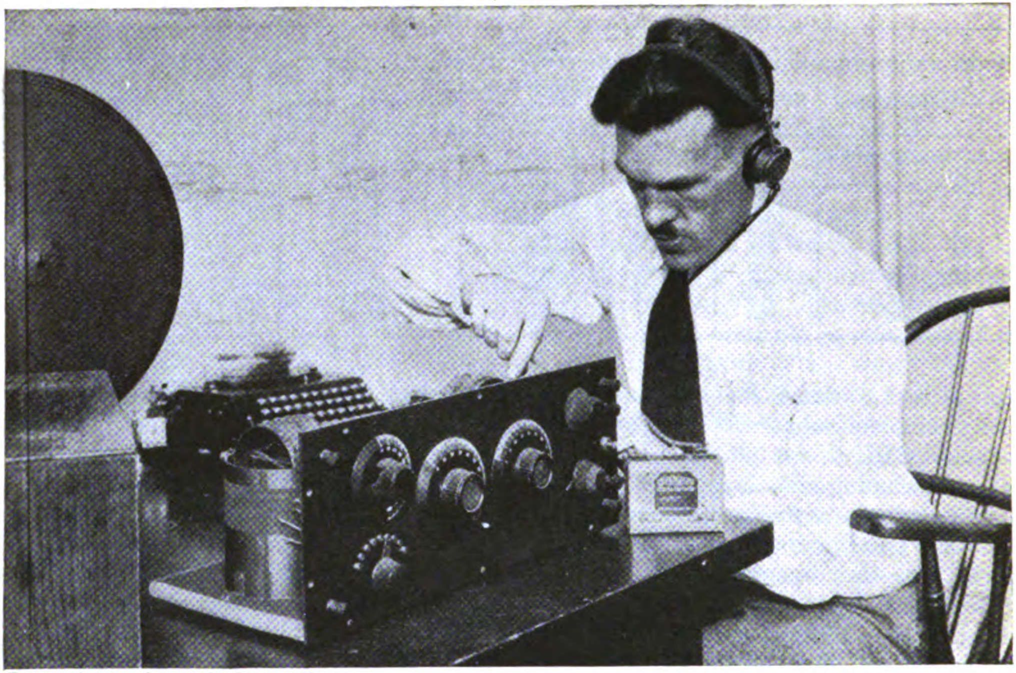
Thin varnishes applied to coils fail to entirely penetrate compact windings, therefore it is improbable that increases in this type is greater than 70 percent above the free coil capacity. One coil being wound up of square cross-section and supposedly well impregnated with liquid bakelite was found to have but the outer portion impregnated as shown in Figure 8 which would be the case for most varnishes applied with a common brush or by simple submersion.

The addition of thin paper insulation in multi-layer coils will not increase the capacity directly, or even approximately, as the constant of the paper. Referring to Figure 9 we have several thicknesses of paper between two successive layers. While the paper is located in position of greatest flux density it does not even approximately occupy the entire electric field which in a large number of turns, is a component of many potentials acting. Though it has a higher centimeter gradient than for air between two turns, it does not occupy such a relative position with respect to the traverse layers or to the entire field acting in the region of the winding. Since the paper is probably less than 0.003 inch thick in most cases, any refraction of flux in it is negligible and the density is not appreciably increased, moreover, traverse layers being further separated tends to reduce the flux and capacity of the winding for a given wire-length. The potentials in a thin segment of a compound dielectric are divided according to the thickness and inductivity of the medium. A potential E acting between two such wires, and through the cotton insulation of thickness d_1, and constant k_1, develops a potential E_1 through the paper of thickness d_2 and constant k_2 according to the formula,

$$E_1 = \frac{E}{\left(1 + \frac{d_1 k_2}{d_2 k_1}\right)}$$

Obviously the comparative thinness of the paper cannot permit a great potential to operate through it except at a small segment where the wires rest on the paper hence the total increase of flux and capacity is slight and is certainly not directly as the inductivity of the paper would indicate.

Apart from the effects of capacity, the effective resistance of inductance coils also involves leakage and other dielectric losses. It is certain that any varnish will improve the insulating properties of raw cotton and silk exposed to moisture as we have shown in Table I.



From a photograph made for POPULAR RADIO

When Your Set Won't Work

Where to Look for Trouble and How to Fix It

By EDGAR H. FELIX, M.I.R.E.

WHEN your first automobile gave trouble, it made some kind of a snort, squeak, wheeze, or dying gasp which gave you a clue to the cause of trouble.

But a radio set just simply stops working.

The powers that operate it are invisible; they do not cause response to our sense of smell, taste or pressure. They respond only to our sense of hearing. These forces are so elusive that a detective cannot trace them. They slip out of the wrong door at the least opportunity, and if you do not treat them exactly as you should they will not serve you.

It is for this reason that radio receiving troubles are so hard to analyze. The only apparent way to find the cause of trouble is to try every connection, every control, every adjustment, one at a time, until you finally hit upon the part out of order or the incorrect adjustment.

There is, however, a sensible, logical, and direct process of analyzing faults in a radio set. In this article I will give you an idea of what to do if your set suddenly stops working.

There are only three general symptoms of trouble which can be detected by the human senses. These three symptoms all appeal to the sense of sound. First, you can easily tell if you are not receiving any signals at all; second, you know when you get an unusually weak signal—much weaker than you are accustomed to hearing from a given station; and, third, you can readily distinguish noisy reception.

Although these three distinctions do not seem to be of particular help, they do enable you to at once eliminate a good many possible causes of trouble and to concentrate upon those which are most likely to be the cause.

What to Do When You Hear No Signal At All

The first of these symptoms of trouble—when you hear no signal at all—is perhaps the least exasperating. There is no question that something is wrong when you do not hear anything. Consequently you set to work to solve the mystery.

If you have been receiving signals nicely, and then suddenly they stop without any apparent cause, look first to the adjustment of your detector.

If you use a crystal detector, monkey with the adjustment until you have found a sensitive spot. In this lies the cause of most of the troubles in crystal detector receiving.

An excellent aid to adjusting a crystal detector is the use of a high-pitched buzzer. Connect with one side of your detector the terminal of the buzzer where the make and break of the connection is made. You can easily identify which buzzer terminal this is by the little spark at the set screw making the contact with the movable arm of the buzzer. This contact is connected directly with one of the two terminals of the buzzer.

When the buzzer is thus connected and operating it will set up magnetic waves in the secondary circuit of your receiver which will enable you to adjust your detector. At various detector adjustments the buzzer sound in the head telephones varies in strength. Leave the detector adjustment alone when you find a good loud point—you are then ready to receive.

When a vacuum tube detector gives no signal at all it is usually a sign that something serious has happened. Vacuum tube detector troubles, however, are not difficult to locate.

Where to Hunt for Vacuum Tube Trouble

The first thing to do is to examine your filaments. Do they light properly and to full brilliancy? If they light at all, the filaments are not burned out. If they do not light when a battery of proper voltage is applied to them, they are burned out. For this there is usually no remedy except to buy new tubes.

But this is not the only possible cause of vacuum tube trouble. The filament may be burning properly; the spring contacts to the prongs of the tube, on inspection, may show that a good contact is being made with each prong, yet you may not hear a sound. Sometimes the new thoriated filament tubes lose their vitality without the filament burning out. If this is the case try out the tube in a tube rejuvenator to restore the thorium to active condition.

Look to your "B" battery, which provides the high voltage for the plate circuit. Are its connections complete? Do you get a loud click in the phones when you disconnect the telephones from the plate circuit? If you do not there is something wrong with the plate circuit. Trace it from beginning to end, from the plate as far as the filament. Try your phone connections. Sometimes one of the cords pulls off the head piece or loudspeaker connections. Sometimes the plug does not make a good contact with the jack.

With some sets there is a variometer in the plate circuit. This variometer makes it a regenerative receiver. Occasionally the connection to the rotor becomes broken from continued use. Examine the leads carefully.

How to Test the Plate Circuit

Touch one of the plate battery binding posts with your wet finger. If your plate circuit is complete, your filaments lit, your "B" battery at full strength and the wiring correct, you should hear a click when you touch the "B" battery binding post with a wet finger. There is something wrong in the plate circuit itself if you do not hear a click under these conditions. It may be with the telephones or the loudspeaker.

How to Check Up Your Antenna

The cause of trouble may lie in the antenna system. A loose antenna connection sometimes makes it possible to hear faint signals, but when your lightning switch grounds the antenna, the chances are that not a sound can be heard in your telephone receivers. Look over the antenna system, trace it through the tuning inductances to the ground connection; trace the secondary circuits of the receiver from the grid connections on the tube bases to the filaments, making sure there are no loose connections with switches, binding posts or movable tuning elements such as variometers and variable condensers.

If your set ever worked at all, a search of the kind I have indicated will locate the cause of trouble.

What to Do When Your Signals Are Unusually Faint

A different kind of trouble may be the cause when you hear only weak signals. Every station comes in evenly and smoothly, but it is only half or one-quarter as loud as usual. This usually happens when you are trying to demonstrate your radio set to friends.

With a crystal receiver the first thing to do is to get a better adjustment of the crystal. If a number of careful attempts of adjustment produce no improvement, look elsewhere for trouble.

With a larger set using radio frequency amplification and a vacuum tube detector there are various possible causes. First, be sure the filaments light to normal brilliancy. It may be that the filament storage battery has run down and needs charging. In that case you do not get proper filament brilliancy.

Another possible cause is a run down "B" battery. Large capacity batteries last from six to twelve months. Some of the small sizes last anywhere from one day to three months. You never know what to expect of a small battery. If the "B" battery has run down, you do not get a sharp click when the telephones or loudspeaker or the "B" battery are suddenly disconnected from the plate circuit. Be sure the filaments are lighted when you make your test.

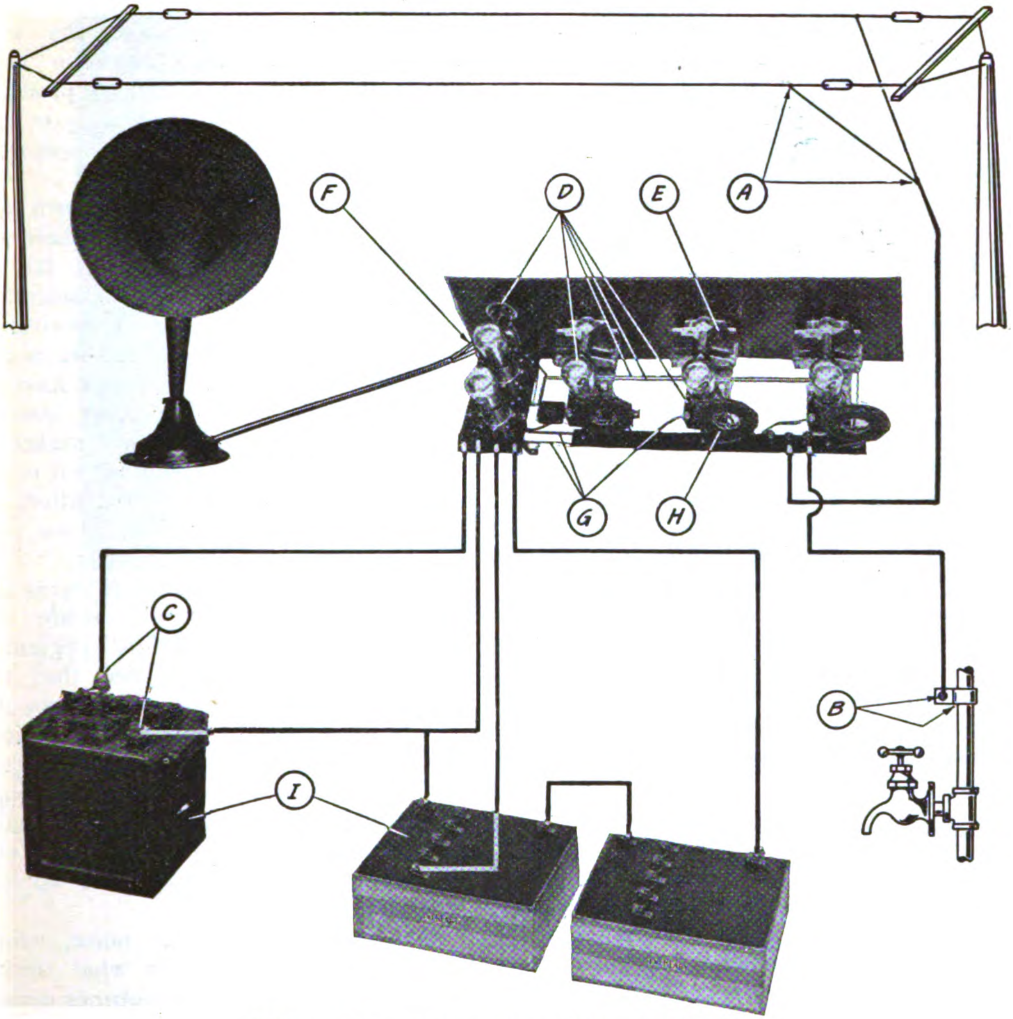
With a home-made vacuum tube set, where the binding posts for the storage battery and the "B" battery are not marked with plus and minus signs, you may make the error of reversing the battery connections. If you have done this, reverse them again so that they are as they should be. The positive terminal of the "B" battery should connect with the plates of the tubes either directly or through the phones and tickler coil.

Another possible cause of trouble is too great a degree of filament brilliancy on the soft detector tube or too high plate voltage or a grid-leak of too high resistance. As you gradually increase the filament brilliancy beyond normal, the first effect is a rapidly increasing hiss. A still greater increase causes a louder hiss until you hear a click and signals stop altogether. Your tube is now what is termed in technical parlance "paralyzed." Under this condition you may sometimes see a faint blue glow around the filament and near the plate. Oftentimes a strong signal from a near-by station tips the balance and causes tube paralysis if the grid-leak is not properly adjusted.

Too much plate voltage also causes the same trouble. Reduce the plate voltage to normal, and decrease the resistance of the grid-leak.

When using a regenerative receiver there is another possible cause for signals dying out. If too much inductance is used in the plate circuit the tube starts oscillating which destroys the tone of all voice and spark signals. A readjustment of plate inductance is necessary to remedy this.

Weak signals are often received when



When Your Receiver Won't Work—

A—See that your lead-in and antenna wires are securely and electrically connected;

B—See that your ground connection has perfect contact with the water pipe, radiator, or other grounding means;

C—See that your "A" battery wires are connected to a clean surface of the lead terminals; the *negative* terminal must go to the *negative* binding post of the set;

D—See if the filaments are lighted. If they are not—

1. See if your socket prongs make contact; if they do not, bend them up higher;
2. See if your "A" battery connections are poor;
3. See if the filament wiring in the set is unsoldered or broken;
4. See if a tube is bad; test it out in another socket to find out if only prongs need bending up;
5. See if the rheostat winding is making a complete connection with its terminals.

E—See that your condenser plates are spaced equally and do not touch each other;

F—Change the phone tips of your loudspeaker terminals, to give best reception;

G—See that all the soldered connections of the grid and plate circuits are all right. If you are not sure that the connection is complete, test it by placing a pair of headphones across the connection with a "C" battery in series with the headphones; if there is a *loud* click the connection is perfect. (This test applies to all connections.)

H—Test the primaries and secondaries of the coils by the headphone-battery method;

I—Test your "B" batteries, which should measure at least 80 percent of original voltage. Your "A" battery should show no less than 1175 on the hydrometer before recharging.

the antenna is disconnected, either by a break in the lead-in or by leaving the switch in the grounded position through an oversight. Trace the entire antenna system through your set. See that good connections are made with the tuning elements. If there is a variometer used, examine the connections. See that the ground lead is unbroken and makes good contact with your ground connection.

Go up on the roof and see if the antenna wire or the lead-in "grounds" at any point. Trace the secondary circuit of your set. You often get weak signals although there is a break in the grid connection to the secondary inductance.

If your trace of antenna and secondary circuits has shown them to be in good working order, the trouble must lie in the tube circuits. Do not overlook the test for phone sensitiveness and condition of "B" battery already mentioned. Your diagnosis, if thoroughly done, is bound to reveal the cause of trouble.

How to Check Noisy and Irregular Reception

The final class of troubles accompany noisy reception. You may for a moment get a good loud signal and then suddenly it dies down; later it comes back in full strength. This is the easiest kind of trouble to locate. But you can only locate this if you keep your temperature below 104 and refrain from getting excited.

When great variation of signal strength attends reception there is a loose connection somewhere. Slowly operate each control of your set, one at a time. If there is a break in the variometer leads or the connections to the switches, you may readily find it by this process. If the trouble lies in a loose connection, sit perfectly still in front of the set for a moment without moving your head or hands and see if any variation in signal strength takes place. If it does not, continue in your search for broken connection. Shake the wire which leads to the telephone head piece or loudspeaker. If that produces a series of clicks and wheezes you may find the copper wire has come loose from the cord tip.

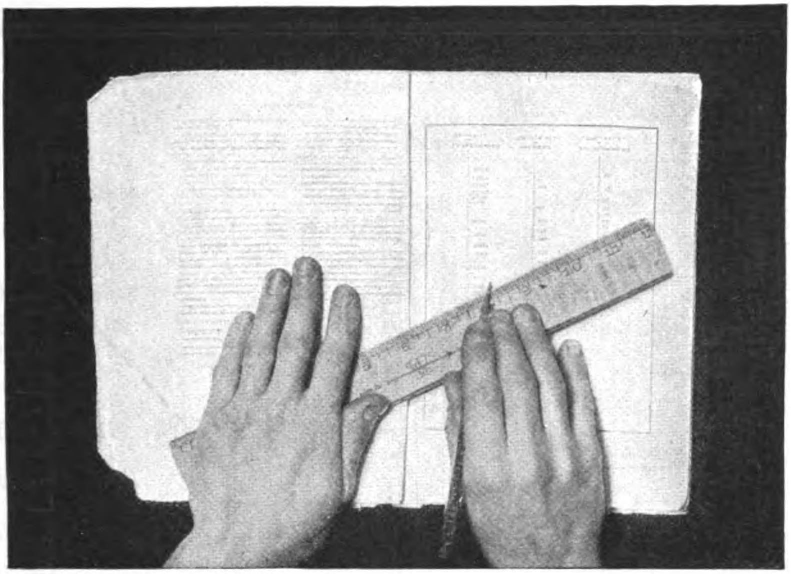
Sometimes the trouble is not with your set at all. It may be that there are variations in the strength of the incoming signal, due either to transmitter troubles or to an absorptive receiver in your immediate vicinity. This is not difficult to diagnose. All you have to do is to tune to some other station, whether spark or telephone, it makes no difference. If a loose connection is the cause of your trouble it will affect all stations alike instead of only one particular station.

If varying the controls and trying the head receivers does not locate the trouble, trace each circuit, beginning with the plate circuit. See that the connections at the base of the tube are good. Trace all the battery connections and the plate circuits. Then trace the secondary circuits from the grid through the inductances to the filaments. Finally trace the antenna circuit from one end through the tuning elements to the ground.

A steady reception of noise, which does not vary no matter what tuning adjustment is used, is sometimes caused by a low "B" battery used with a reflex receiver. It is often possible to get additional service from such "B" batteries by using them on non-reflexed tubes. With heavy current drain sets extra large "B" batteries give the most economical service in cost her hour of use. Another cause of noise may be vibrating tubes caused by building vibration, typewriters or nearby machinery.

There are other causes of trouble but these which I mention constitute the 99 percent of them all. The remedy in each case is simple and obvious once the cause is located.

Once you have successfully discovered a trouble, the next time it occurs you can locate it in an instant.



From a photograph made for POPULAR RADIO

HOW TO SCALE OFF THE ANSWER TO YOUR RHEOSTAT PROBLEM

First determine the positions on the charts where the known specifications are located; then connect these points with a ruler which will fall upon the reading you seek.

A MEASUREMENT CHART

FOR USE WHEN SELECTING A RHEOSTAT FOR A MULTI-TUBE CIRCUIT

Article No. 13

By RAOUL HOFFMAN, A.M.E.

TO control more than one tube by a single rheostat simplifies not only the building of a radio set, but reduces the contacts in the filament circuit; and thus adds to the efficiency of a radio receiver.

Difficulty is often encountered in the selection of the proper rheostat.

Applying Ohm's law to the filament circuit, we have

$$\text{Amperes} = \frac{\text{Voltage}}{\text{Resistance}} \quad \dots\dots\dots\dots \quad 1$$

where the resistance is equal to the sum of the resistance of the rheostat and the resulting resistance of the parallel-connected tubes.

By connecting tubes in parallel,* the resulting resistance will be inversely proportional to the number of tubes used; therefore equation (1) will be

$$n \times \text{Amperes} = \frac{\text{Voltage}}{R + \frac{R_T}{n}} \quad \dots\dots\dots \quad 2$$

or

$$\text{Amperes} = \frac{\text{Voltage}}{n\,R + R_T} \quad \dots\dots\dots\dots \quad 3$$

wherein n denotes the number of tubes, R the resistance of the rheostat, R_T the resistance of a single tube.

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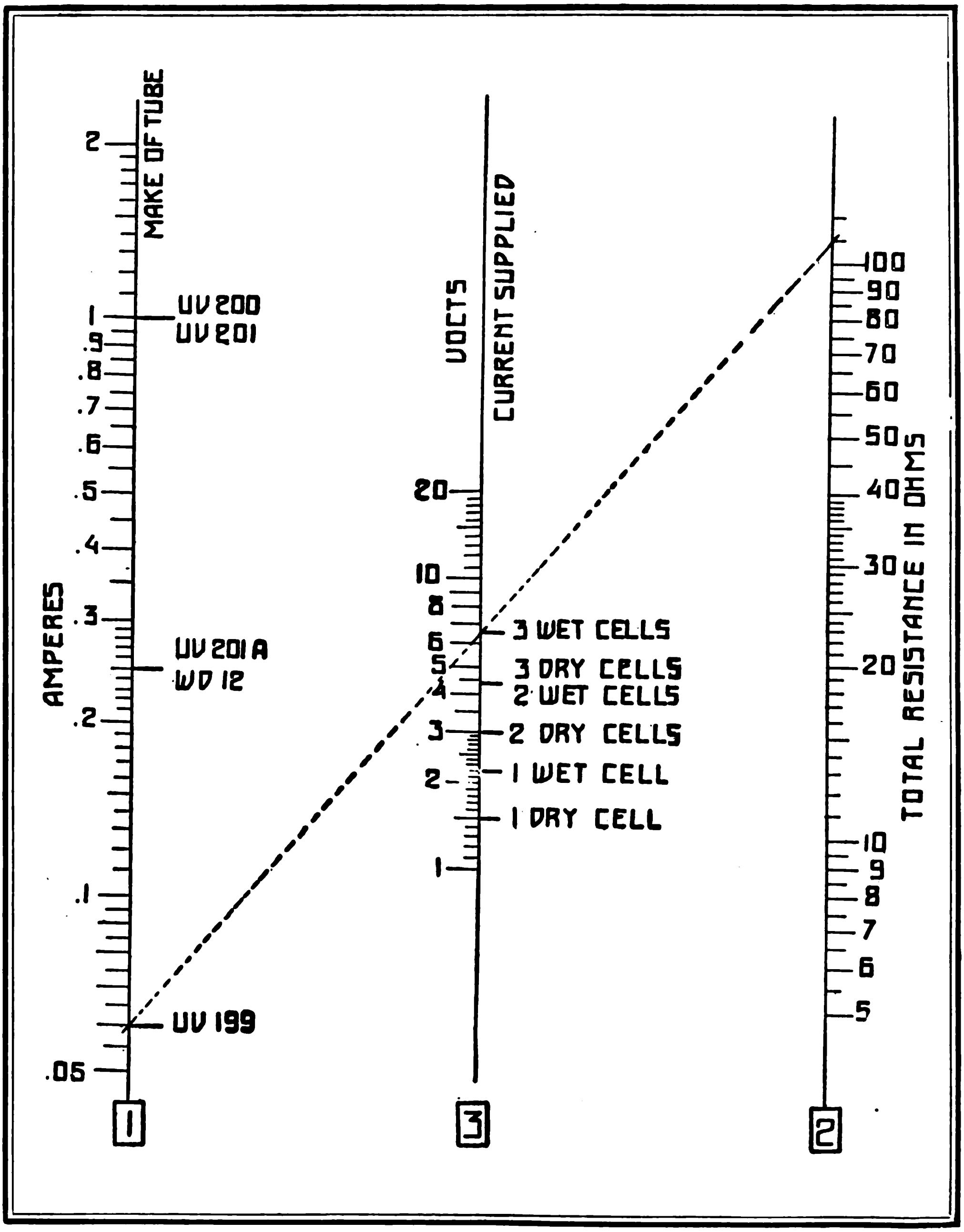
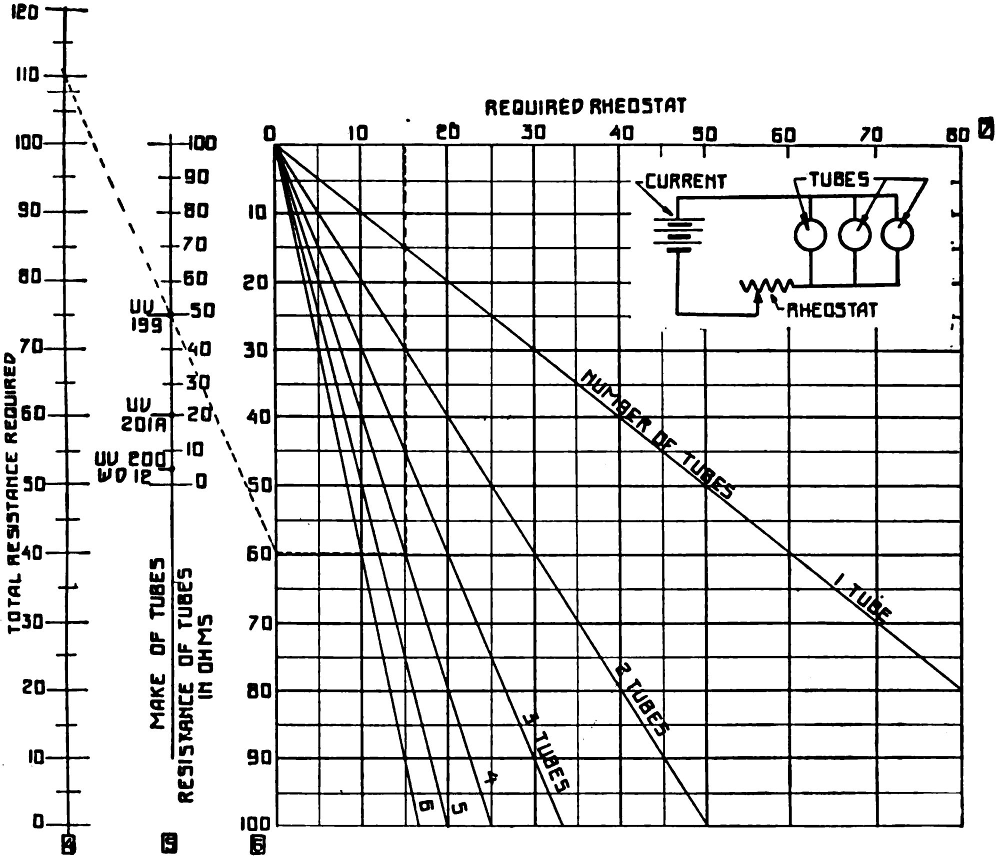
* See January, 1925 issue of POPULAR RADIO, page 58.



MAKE YOUR CALCULATIONS ON THIS TABLE

FIGURE 1: *The text of this article tells you just how to figure out the proper resistance for the rheostat to employ in radio receiving circuits with various "A" battery voltages.*

To evaluate equation No. 3 we find first, with the aid of equation No. 1, the total resistance required, then subtract the resistance of a single tube and divide the remainder by the number of tubes to be used, then add 2 to 3 ohms for control of the filament, to get the correct rheostat.



THE SUPPLEMENTARY CHART

Figure 2: *This chart used in conjunction with that in Figure 1, indicates the proper resistances to use for a number of tubes. The text explains in detail just how these charts are used.*

For ready calculations, the chart in Figure 1 will eliminate mathematical operations as follows:

We have a three-cell storage battery (6.6 volts) and want to know the rheostat required for controlling four UV-199 tubes connected in parallel.

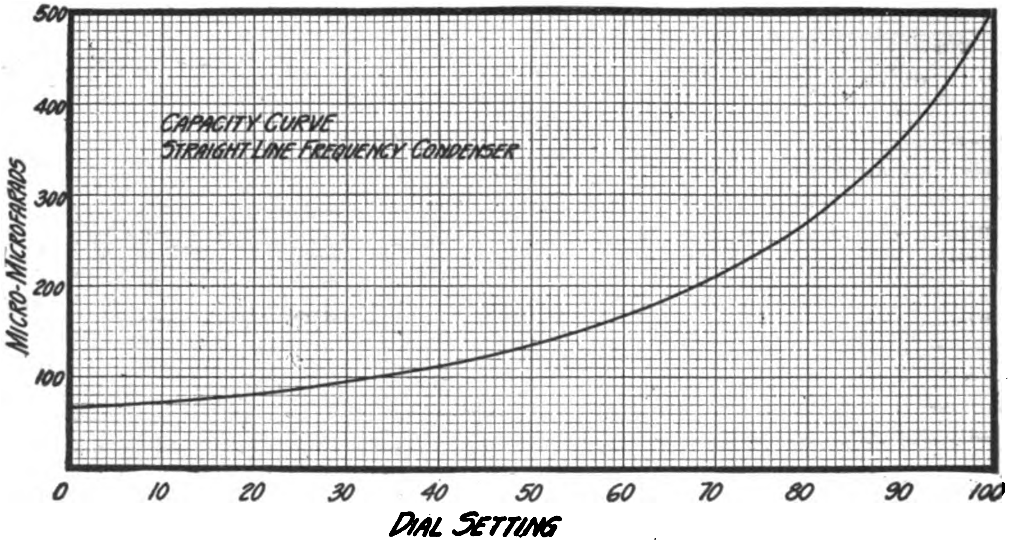
Connect UV-199 on scale No. 1 with "3 wet-cells" on scale No. 3. You will find on scale No. 2 the resulting resistance of 110 ohms.

Then draw a straight line through 110 on scale No. 4 in Figure 2 and UV-199 on scale No. 5 intersecting 60 on scale No. 6; following horizontally to "4 tubes," then vertically to the scale No. 7, you will find the required rheostat is of 15 ohms, and adding 3 ohms for control, you will have a rheostat of 18 ohms to suit conditions.

To obtain best results the "characteristics" of the tubes should be the same.

Another Hoffman Measurement Chart—

for the simple calculation of inductance of toroid coils—will appear in a near issue of Popular Radio. *Keep these charts for reference in your experiment work.*



IDEAL CAPACITY CURVE FOR THE NEW SLF CONDENSER

FIGURE 1: *This diagram shows the necessary variation of capacity of a straight line-frequency condenser with the setting of the tuning dial. Notice that at the lower settings the rate of increase is slow but at the higher settings the rate of increase increases greatly.*

THE PART THAT YOUR CONDENSER PLAYS IN

TUNING

What is the difference between "straight line capacity," "straight line wavelength" and "straight line-frequency" condensers? Just how do they affect tuning? What system gives the best tuning facilities? The answers are in this article.

By HERBERT J. HARRIES

WHEN KDKA was the only broadcasting station working on a regular schedule, and tuned-radio-frequency circuits were not as popular as they are today, a condenser was a condenser and it made little difference whether the plates were square or circular or what shape they were so long as the capacity was variable.

In 1925, A.D., however, with nearly six hundred broadcasting stations sharing the relatively few frequency bands at the disposal of the Department of Commerce, the situation is decidedly different. Between the Atlantic and the Pacific there probably is not a single "BCL" (broadcast-listener) who has not done considerable "cussing" at one time or another, mentally or orally, because he found that his receiver tuned so broadly on the higher frequencies (lower wavelengths) that separating the multitude of stations concentrated on the first 30 or 40 divisions of his dials was an impossibility.

Everyone knows that this situation exists, but no one seems to have made a careful analysis as to *why* it exists.

Why must we be content with broad tuning on the higher frequencies when the same coil and condenser tune "sharp as a needle" on 550 to 650 kilocycles? Is it not possible to build a condenser which will have more nearly uniform tuning characteristics?

And the dials most commonly used have the 180-degree tuning range calibrated uniformly from 0 to 100. Is it not possible to shape the condenser plates so that one frequency band of 10 kilocycles will correspond to one degree on the dials? In other words, if WCAE transmitting on 650 kilocycles tunes in at 90, why can we not make the condensers so that KSD on 550 kilocycles will tune in at 100, WHT on 750 kilocycles at 80, WWJ on 850 kilocycles at 70 and so on?

Is it possible to do these things?

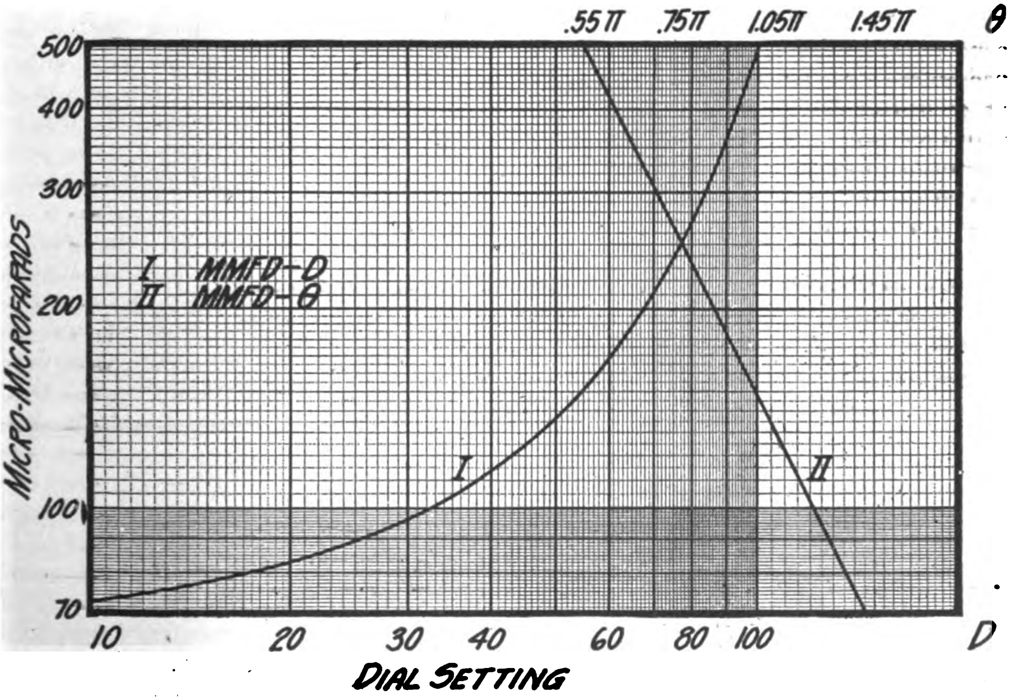
Let us consider first the matter of broad tuning at the higher frequencies.

Obviously a circuit which tunes sharply at one dial setting is not going to tune broadly at another unless its resistance has been materially increased. Apparently then, as we reduce the capacity of the condenser we increase the resistance of the resonant circuit.

Suppose we consider it from another point of view. When the capacity is maximum, the full area of the rotor plates is in close relation to an equal area of the stator plates with nothing between them but some thin sheets of the best dielectric known—air. The dielectric losses are extremely low, and the 550 kilocycle current has presented to it a path of very low resistance.

As we reduce the capacity, however, we reduce the area of the rotor plates that is close to the stator plates and likewise reduce the area of the dielectric path through the air. Finally, as we continue to reduce the capacity we reach a point where the path through the air constitutes a relatively small portion of the dielectric circuit. Consequently, most of the current is forced to flow through the solid dielectric used to support the plates and the dielectric losses become exceedingly high. The resistance at 0 dial setting may be as high as 10 to 20 times the resistance at full capacity.

This increase in resistance does not take



THIS CURVE SHOWS CAPACITY AGAINST DIAL SETTING

Figure 2: *The values are here plotted on logarithmic co-ordinates. If a simple relation were to exist between the dial setting and the capacity, curve 1 would be a straight line. This is a proof that the curve is not a simple hyperbolic.*

place at a uniform rate by any means. Down as low as 40 on the dial it may be scarcely perceptible, but somewhere between 20 and 40, depending upon the shape of the plates and the excellence of the condenser, it begins to rise quite rapidly. It is interesting to note that of two condensers of present day design and equal excellence of construction, the one with circular plates will show the lower resistance at say 20 or 10 on the dial.

To maintain sharp tuning then, as the capacity of the condenser is reduced, it seems apparent that we need only to provide a low resistance path for the current at the lower dial settings. That would not be so difficult if we could manage to mount the plates on air.

Now let us drop that consideration until later on and give some thought to the question of using 100 percent of our dials and having the stations spaced uniformly around them. The data given in Table 1 will be of assistance. Assuming that our tuned circuit contains a low-loss inductance of 168 microhenries and a variable condenser of 500 micro-microfarads capacity, the actual tuning capacity needed at each 100 kilocycle step between 550 and 1,550 kilocycles has been calculated from the formula

$$C = \frac{159200^2}{f^2 L}$$

where C = capacity in micro-microfarads, f = frequency in kilocycles, and L = inductance in microhenries. A condenser with a maximum capacity of 500 mmfd. was chosen for no particular reason except that the writer is a firm believer in keeping the coil resistance down to a reasonable figure, and that does not, in general, permit the use of coils of 300 to 400 millihenries inductance.

The table gives the numerical values of the capacity needed at each tenth division on the dial to space the stations uniformly around it. Perhaps we can visualize these capacity requirements a little more easily by plotting them against the dial settings on rectangular co-ordinates, as is done in Figure 1. It is a hyperbolic curve, as the formula from which we calculated the values for C told us it would be, but it is not a simple hyperbolic curve. We can prove this easily by plotting the same values on logarithmic co-ordinates, as is done in Figure 2. If a simple relation existed between C and the dial setting D, curve I would be a straight line. The fact that we get a curve shows that no such simple relation exists. This will be considered further later on.

To digress for a moment, let us see what results we would get by using either one of the two types of condensers most commonly used at present, the circular plate (straight-line-capacity) type and the square-law (straight-line-wavelength) type.

First, for each type, we must plot a capacity-dial setting curve as in Figure 3 where I, the straight line, is the curve of the circular plate condenser and II is the curve of the square-law condenser.

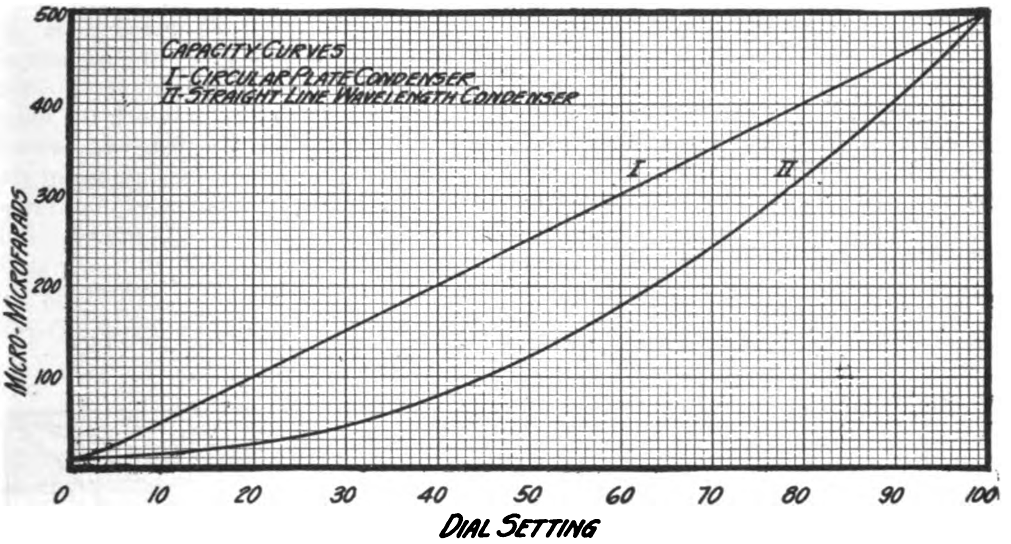
Then by plotting the capacities in Table

TABLE I

Frequency kilocycles	Inductance mh.	Capacity mmfd.	Dial setting
550	168	500	100
650	168	358	90
750	168	269	80
850	168	209	70
950	168	168	60
1050	168	137	50
1150	168	114	40
1250	168	97	30
1350	168	83	20
1450	168	72	10
1550	168	63	0

TABLE II

Frequency kc.	Capacity mmfd.	θ	(D)
550	500	0.55π	(100)
650	358	0.65π	(90)
750	269	0.75π	(80)
850	209	0.85π	(70)
950	168	0.95π	(60)
1050	137	1.05π	(50)
1150	114	1.15π	(40)
1250	97	1.25π	(30)
1350	83	1.35π	(20)
1450	72	1.45π	(10)
1550	63	1.55π	(0)



THE CAPACITY CURVE FOR TWO TYPES OF CONDENSERS
FIGURE 3: *Curve I shows the capacity variation of a straight line-capacity condenser and curve II shows the capacity variation of a straight line-wavelength condenser.*

I against the corresponding dial settings from Figure 3 we can determine where the different stations will come in on the dial. This is done in Figure 4, where curve I is that of the circular plate condenser and curve II is that of the square-law condenser. Curve III is added to show what we would get if the frequency bands were uniformly distributed over the 100 divisions on the dial.

An analysis of Figure 4 is quite illuminating. It shows us that, contrary to the generally accepted belief, the circular plate condenser is to be preferred for this particular combination of capacity and inductance. Only the lower 13 divisions on its dial are unused in covering the broadcasting frequency range whereas the lower 35 divisions of the square-law condenser are of no service.

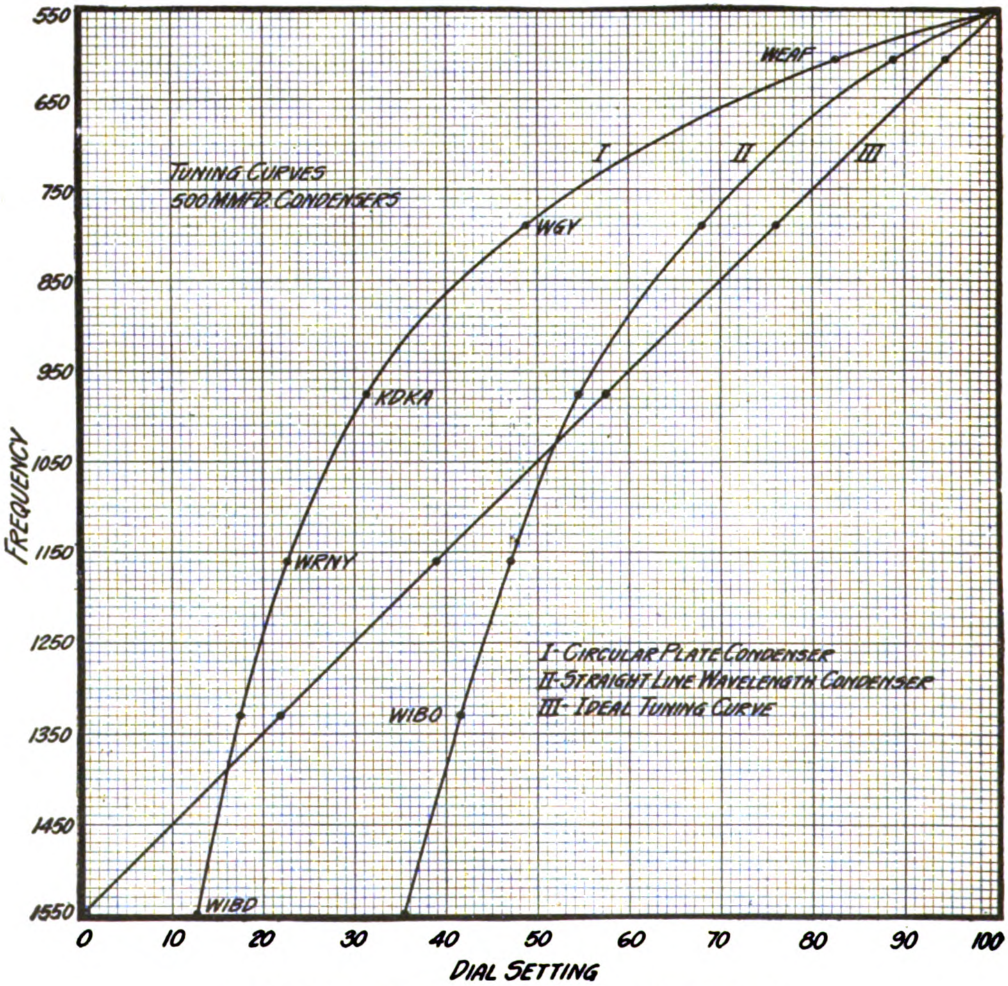
We could extend the usefulness of the latter by doubling the inductance and halving the maximum capacity, that is, by using a 250 mmfd. condenser instead of one with 500 mmfd. maximum capacity. But in doing so we would just about double the resistance of the coil. Also, the resistance of the 250 mmfd. condenser below about 30 on the dial would be so great that the tuning would be broad. The net gain would probably be negative, assuming that a low-loss inductance was used and the 500 mmfd. condenser would probably prove more satisfactory, so far as selectivity and sensitivity were concerned, even though the dial range would be 13 percent smaller.

Let us make one more comparison before we drop the circular plate and square-law condensers from the discussion. If we could straighten the circular edges of the dials out and lay them side by side we would get a very clear picture of the relative amount of crowding we would experience with each condenser. This has been done, theoretically, in Figure 5 where the 100 divisions are represented as lying in a straight line. The number of 10 kilocycle frequency bands included within each ten divisions is clearly shown, and the desirability of the condenser which has the characteristics pictured in Figure 5-C is very apparent.

Having satisfied ourselves that our theoretical condenser will be much more satisfactory than circular plate and square-law condensers, we now have before us the problem of shaping the plates so as to provide those characteristics.

Figure 1 gives us a picture of the condenser we propose to design. The maximum capacity will be 500 mmfd. and down to 70 or 60 on the dial it must decrease rapidly. As a matter of fact, the formula tells us it must decrease in inverse proportion to the square of the frequency corresponding to each dial setting, as given in Table I.

Now we have another point to consider. It has been customary heretofore to design condensers with as low minimum capacity as could possibly be obtained with the exercise of the utmost ingenuity. Careful designers have turned out condensers in which the minimum capacity was less than two percent of the maximum. A fair figure for the lowest possible minimum of our condenser would be about 10 mmfd. But Table I shows that our capacity at 0 dial setting is 63 mmfd. Where on the dial can we put those 53 mmfd. we are "long"?



A TUNING CURVE FOR THREE CONDENSERS

FIGURE 4: *Curve I is the frequency against dial-setting curve for the straight line-capacity condenser. For this combination of capacity and inductance, the straight line-capacity condenser is to be preferred to the straight line-wavelength condenser as there are only thirteen unused divisions on the dial setting as against thirty-five divisions in the case of the latter.*

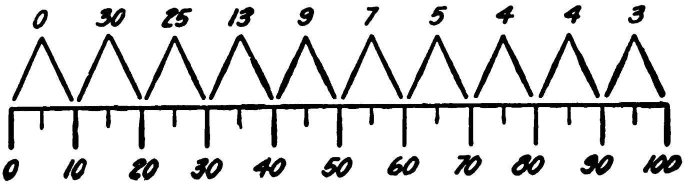


Figure 5A: *This drawing shows the number of ten kilocycle bands included in each ten degrees on the dial for curve I in Figure 4.*

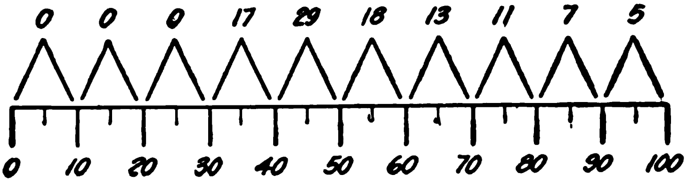
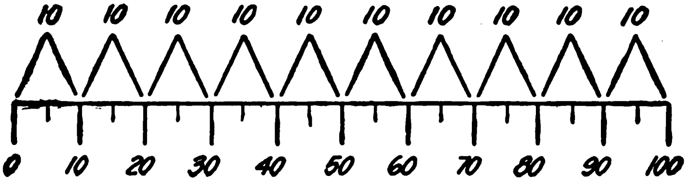


Figure 5B: *In this diagram is shown the number of ten kilocycle bands included in each ten divisions for curve II in Figure 4.*



IDEAL TUNING DISTRIBUTION

Figure 5C: *Notice that the frequencies are evenly distributed over the entire dial setting, so that every ten division covers a frequency range of 100 kilocycles. This is true of the curve III which is shown in Figure 4, for a straight line-frequency condenser.*

Why put them on the dial at all? Just because it has been customary for the range of a condenser to be from the maximum to the lowest possible minimum is not a good reason for continuing the custom. And since we do not need those 53 mmfd. as variable capacity for tuning why not leave them in the condenser as a fixed capacity. This may sound like rank heresy to those who have exerted every effort to get a low minimum, but to the writer it sounds logical.

And somewhere back there we needed a low resistance path at low dial settings so the current would not be forced through the solid dielectric. Here is where we get it. We just take those 53 mmfd., spread them out over some circular brass or aluminum plates, provide some thin sheets of perfectly good air and there we are!

Now let us take a look at Figure 6-a which shows us the approximate shape our rotor plates will assume. What form the stator plates take is immaterial so long as we can provide convenient mounting means.

We have decided that a part of each rotor plate will be a circle. Consequently, no matter what the dial setting, the projection of the circle upon the stator plates, shown shaded in Figure 6-b, will be invariable and great enough to provide our 53 mmfd. All we have left to do now is to determine the exact shape of the rotor plates which will give us the capacity curve in Figure 1. The approximate shape is shown dotted in Figure 6-a and Figure 6-b.

Determining the equation of the boundary curve would not be difficult if a simple relation existed between any value of capacity and the corresponding dial setting. But we proved by curve I in Figure 2 that no simple relation exists.

We can consider this in another way., Our formula

$$C = \frac{159200^2}{f^2 L}$$

can also be written

$$C = \frac{a_1}{f^2}$$

where $a_1 = 159200^2/L$. Also, since we wish to distribute the frequency bands uniformly over the dial, we should be able to write

$$f = a_2 D$$

where a_2 is some constant. Then we could substitute $a_2 D$ for f in the preceding formula and get

$$C = \frac{a_1}{a_2^2 D^2} = \frac{a}{D^2} \quad (a = a_1 / a_2^2)$$

But this is not true because the preceding equation is not true.

Suppose we check the latter against Table I. When $D = 100$, $C = 500$, then

$$500 = \frac{a}{100^2}, \text{ and } a = 5 \times 10^6$$

Using other values of D we get

when $D = 70$, $C = 1020$
$D = 40$, $C = 3125$
$D = 10$, $C = 500000$

which do not check at all with the values we have listed in Table I.

This discrepancy is due to the fact, as we stated before, that no simple relation exists between C and the corresponding setting D. But the boundary curve is a hyperbolic spiral, from our original formula, so the formula

$$C = \frac{a}{D^2}$$

would be true if D were properly expressed. If, instead of D, we use another designation, θ, for the dial setting and in addition have the dial read backwards for purposes of calculation, we can give values to θ for which the formula will be true. We therefore prepare Table II and use it instead of Table I.

We now find that whereas our previous formula

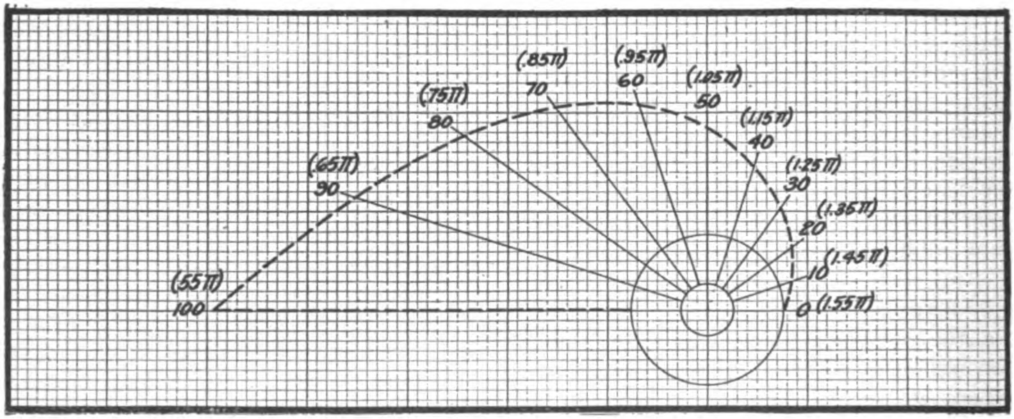
$$f = a_2 D$$

was true for only one value of D and not for any other, the corresponding formula

$$f = k_2 \theta$$

is true for all values of θ listed in Table II. Substituting this expression for f we now have

$$C = \frac{k}{\theta^2}$$



THE SHAPE OF THE ROTOR SECTION

FIGURE 6A: *The correct curve for the rotor plate shape for a straight line-frequency variable condenser that will give the variation of capacity as shown in Figure 1 and that will give the tuning characteristics shown in curve III in Figure 4.*

and we find that this is true for any value of θ given in the table, for when values of C are plotted on logarithmic co-ordinates against the corresponding values of θ we get the straight line marked curve II in Figure 2.

If we had not decided that part of each rotor plate would be a circle, the outline of the plate could now be expressed

$$R_1 = \sqrt{\frac{4k}{\theta^3}}$$

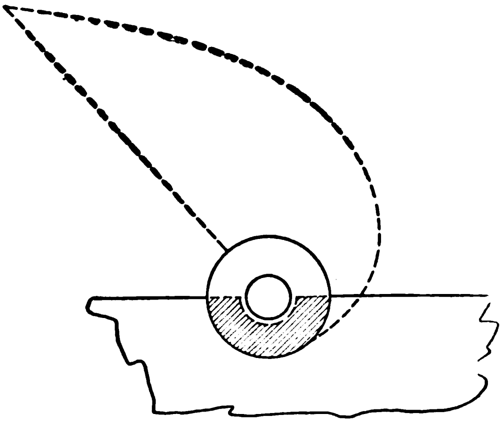
But we have to take the circle into consideration, as well as the semi-circle cut-out of the stator plates to accommodate the shaft, so our final formula becomes

$$R_1 = \sqrt{\frac{4k}{\theta^3} - R_2^2 + R_3^2}$$

where R_1 = the radius of the hyperbolic section, R_2 = the radius of the circular section, and R_3 = the radius of the semicircle cut out of the stator plates.

We can now replace our specially-calibrated, backward-reading dial by a standard one reading 0 to 100 and if our coil is of the proper inductance we will find the stations between 550 and 1,550 kilocycles uniformly distributed over 100 percent of our dial, as shown by curve III, Figure 4 and in Figure 5-c. Also, we have taken advantage of a fact incident to the design of inverse-square-law condensers, whereby they must be designed with some pre-determined minimum capacity, by making that minimum more than six times its customary value and using it to provide a low resistance path for the current at low dial settings.

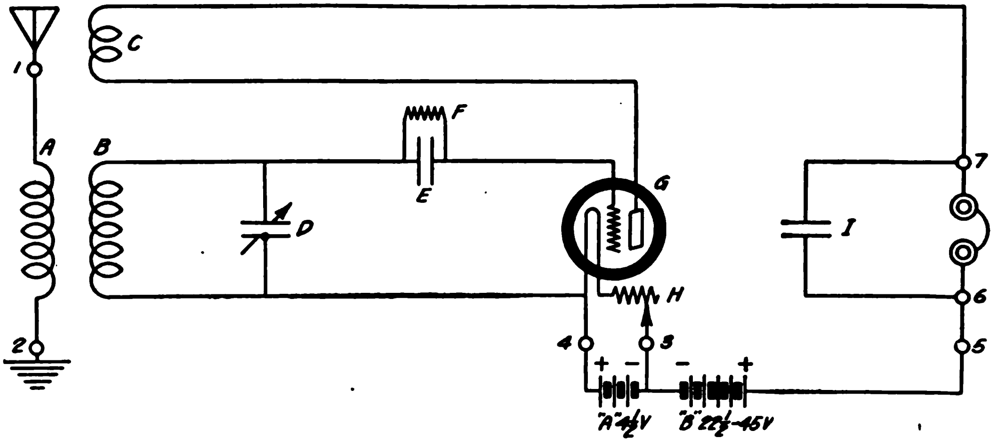
In the foregoing we have not taken into consideration the capacity of the coil. This, of course, would affect the radius of the circular portion of the plate and would have to be considered in determining suitable dimensions. Also, it will be apparent to the thoughtful reader that a condenser of this type must be used with a definite coil if absolutely straight-line characteristics are to be maintained. The writer has not determined to exactly what extent a certain percentage variation in inductance would affect the straight-line tuning characteristic but it would be inappreciable, in all probability, over a range of plus or minus ten percent.



ANOTHER DRAWING OF THE ROTOR SECTION

FIGURE 6B: *The projection of the circular part of the rotor plates upon the stator plates. This area will be invariable, as the condenser is rotated and should be great enough to provide the 53 mmfd. shunt capacity that should be spread out over the whole dial setting.*

In conclusion, it should be noted that a square-law condenser should be designed to cover a pre-determined wavelength range, and an inverse-square-law condenser should be designed to cover a pre-determined frequency range, which corresponds in each case to the broadcast range. If this is not done, the broadcast range, in which probably 95 percent or more of the users of this class of apparatus are interested, will be concentrated on 60 to 85 percent of the dial and the remainder will be useless. Keeping this in mind, it is obvious that if we design the condenser so as to get the lowest minimum possible, in line with present practice, the tuning range of the condenser will be much greater than is needed. To get the full benefit of the 100 divisions on our dials we must provide a pre-determined minimum *which is greatly in excess of present practice!* This is no real disadvantage for the high minimum provides a low resistance path for the current at low dial settings and thus reduces the resistance of the tuned circuit by a very considerable amount.



THE THEORETICAL CIRCUIT DIAGRAM

FIGURE 1: *This drawing shows the general circuit connections for the various instruments that go to make up the receiver.*

Simple "How-to-Build" Articles for Beginners
No. 14

How to build a one-tube regenerative receiver for use with the new UX-199 tube

By LAURENCE M. COCKADAY

COST OF PARTS: *Not more than $19.00*
APPROXIMATE RANGE: *1,000 miles*

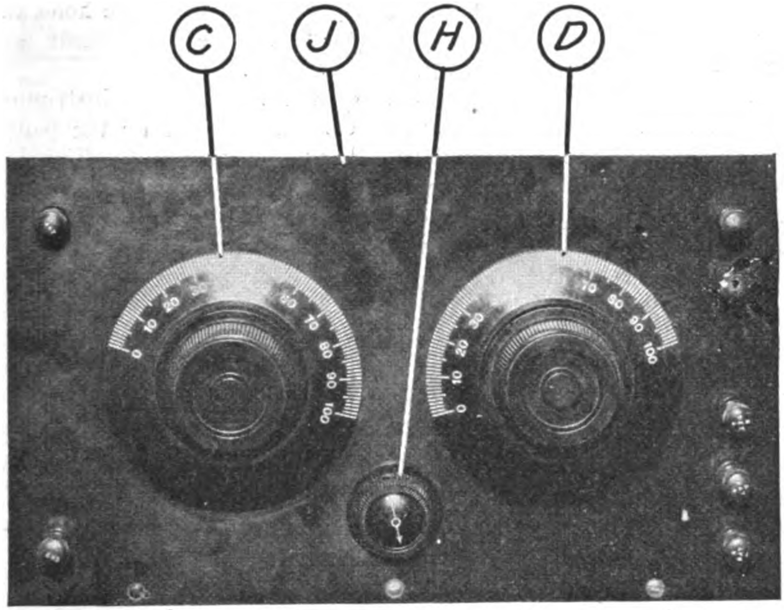
HERE ARE THE ITEMS FROM WHICH THE LABORATORY MODEL WAS BUILT—

A, B and C—primary, secondary and tickler coils of Aero coil three-circuit tuner;
D—Continental Separator (variable condenser), .0005 mfd.;
E—Sangamo fixed condenser, .00025 mfd.;
F—Electrad grid-leak, 3 megohms;
G—Pacent socket No. 82 for UX-199 tube;
H—Carter "Imp" rheostat, 25 ohms;
I—Sangamo mica fixed condenser, .002 mfd.;
J—composition panel, 7 by 12 inches;
K—hardwood baseboard, 7 by 10 inches;
Seven Eby binding posts;
Two large Century dials.

THE latest addition to the series of simple sets for the beginner is more than just an ordinary dry-cell set. It was especially designed to be used with the new UX-199 for quality reception combined with selectivity and long distance-getting ability. This receiver will be found to be an easily operated set and will enable the beginner to tune out the local stations and bring in the distant ones on headphones. It uses finely designed and manufactured apparatus throughout and may be considered the nucleus of a receiver that may be added to from time to time to make a really fine loudspeaker set. It operates directly from three dry-cell batteries for the "A" battery and one 22½-volt or 45-volt "B" battery.

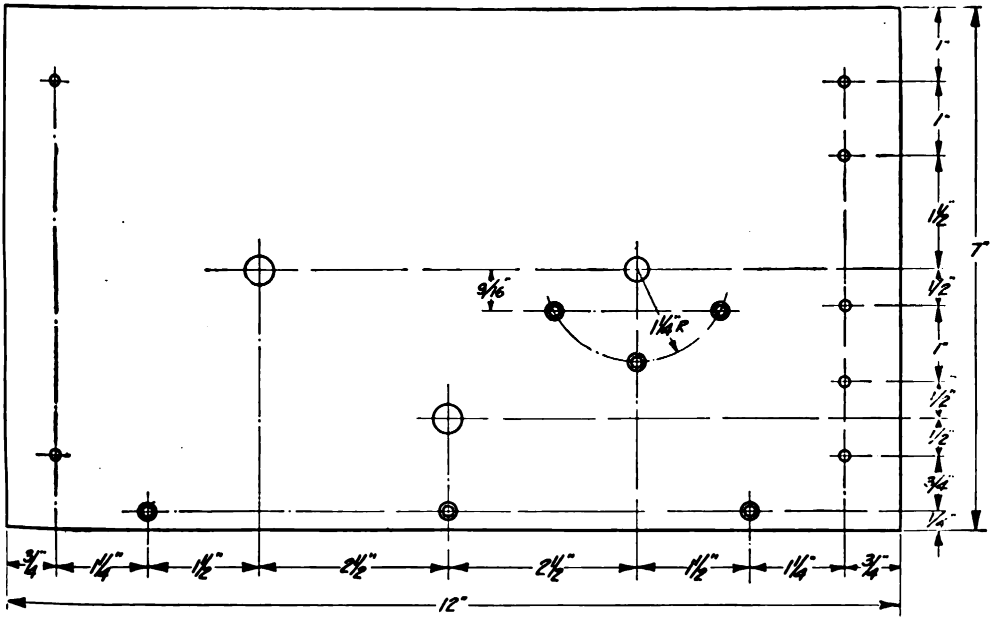
The set is regenerative and the coupler used gives a nice control of the regeneration. The secondary coupling to the antenna is controlled by a semi-variable coil A shown in Figure 4.

The tickler coil is controlled by the dial C which is attached to the coil C as shown



VIEW OF THE PANEL FROM THE FRONT

Figure 2: *This picture gives the general arrangement of the front panel with the two large dials, the small rheostat dial and the seven binding posts mounted in the correct positions.*



THE DRILLING PLAN FOR THE PANEL

Figure 3: *In this drawing are shown the exact locations for the holes that are to be drilled in the panel for mounting the instruments and the binding posts. The holes outlined with a double circle should be countersunk.*

in Figure 2, which is the front view of the set.

The unit that is described here was built and carefully tested in the POPULAR RADIO LABORATORY. The construction of the set is simple and the completed receiver, as stated before, is easy to operate.

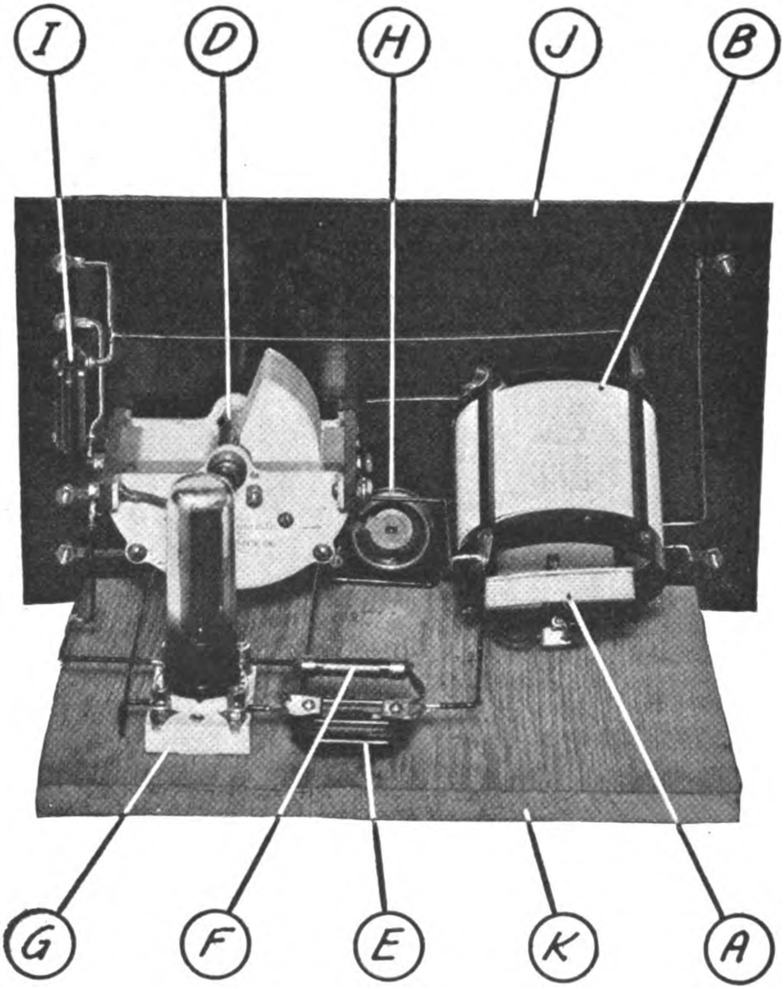
Take this issue of the magazine to a radio store and ask the dealer to give you exactly the same parts as those that are included in the list at the beginning of this article.

Then take the parts home and drill the panel J (as shown in Figure 3) which gives the size of the panel and the correct spacing for all of the holes that are used to mount the instruments and the binding posts.

Then, mount the instruments in their correct positions on the panel and baseboard as shown in Figures 4 and 5. When this is done, wire up the instruments with standard, round bus wire, as indicated in Figures 1 and 5.

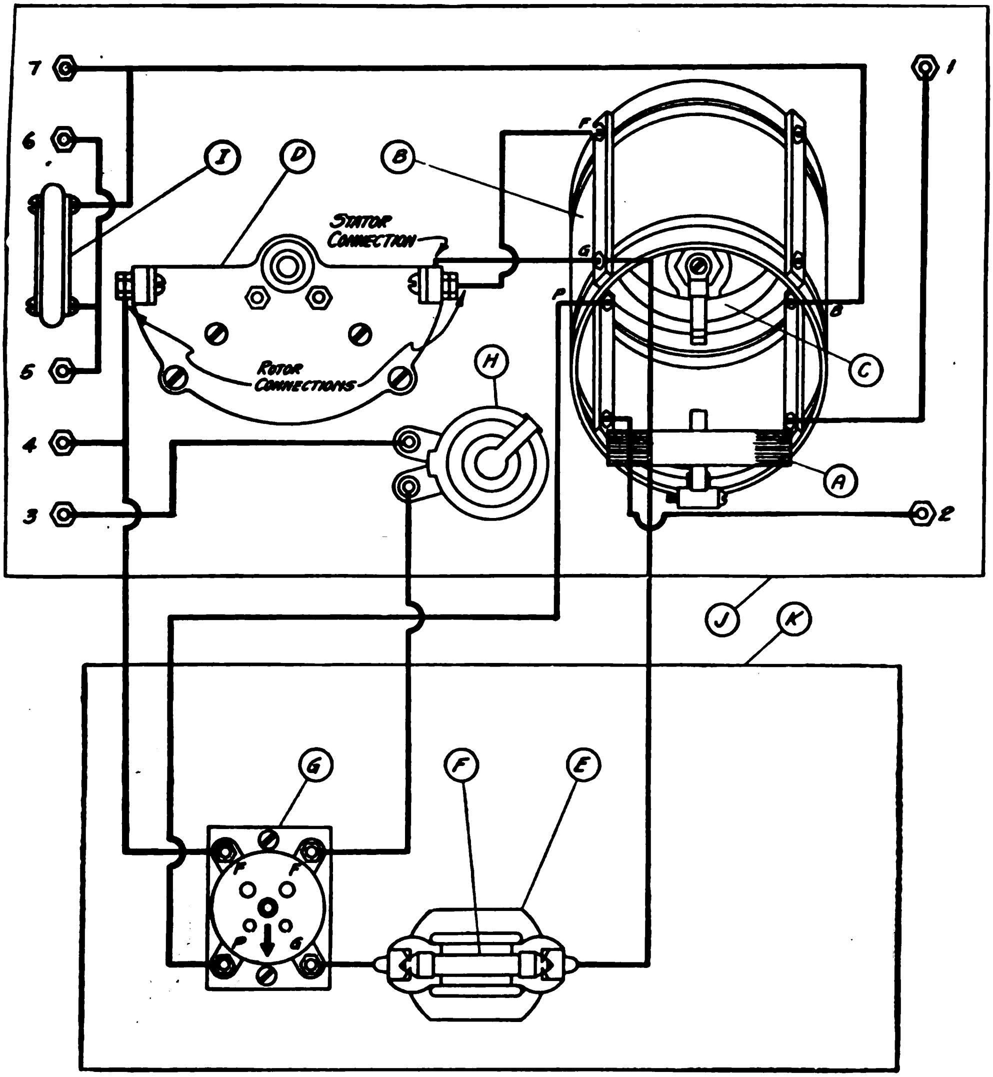
When you have finished wiring up connect the antenna, ground and batteries (see Figure 1) to the binding posts and then you are ready to listen in.

To tune the receiver all that is necessary is to revolve the dial D, with the



VIEW OF THE SET FROM THE REAR

FIGURE 4: *Here are shown the various instruments mounted on the back of the panel and on the sub-base with the connecting wires in place.*



THE PICTURE WIRING DIAGRAM

FIGURE 5: *In this diagram the exact way to run the wires is shown. The upper rectangle represents the panel and on it are shown the instruments which are drawn in about their relative positions. The lower rectangle represents the baseboard and on it are shown the socket and the grid-leak and condenser.*

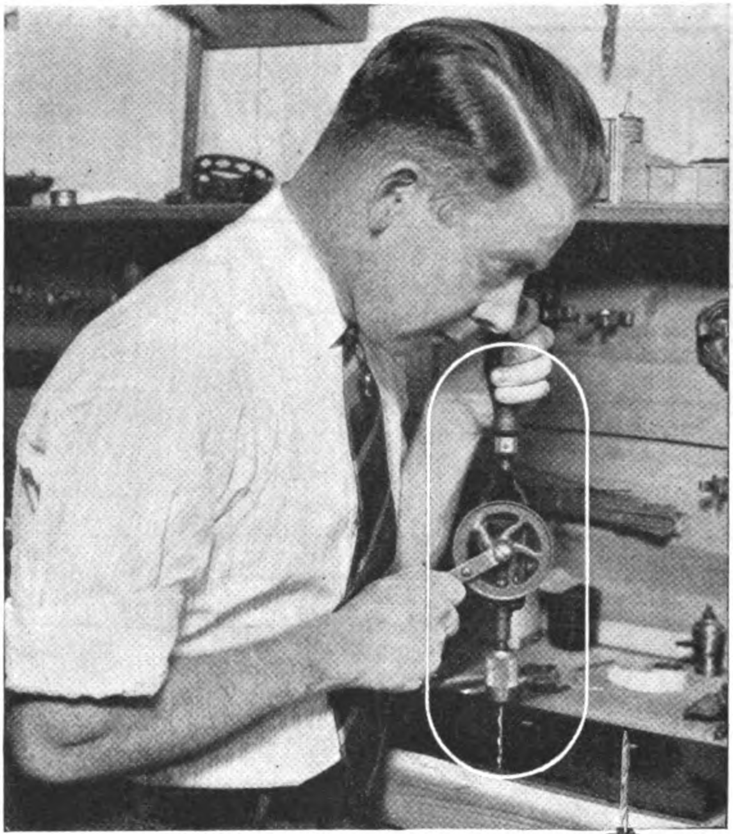
dial C set at a rather low value and the small knob H turned so that the filament of the vacuum-tube lights with the correct brilliancy.

When a signal is tuned in, the dial C may be adjusted so that the signal comes in loudest and clearest. Some other small adjustments may then be made by the small dial H and the dial D for final settings.

The correct type of antenna to use with this receiver is a single wire of about 100 to 150 feet in length.

If the set is built correctly as shown in the pictures and diagrams, the operator, after he becomes familiar with the tuning, will find that he will get exceptionally good reception on the headphones from stations up to an average distance of about 1,000 miles.

Handy Tools for Radio Fans: No. 9



From a photograph made for POPULAR RADIO

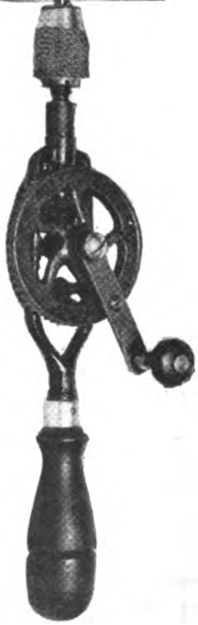
THE HAND DRILL

A useful tool for preparing panels

THE radio experimenter who likes to build his own set will find a drill of this type nearly indispensable when he comes to the point of drilling the panel to mount his instruments.

The drill is composed of a long handle frame to which is attached a large and small beveled gear. A crank is attached to the large gear while the smaller is fastened to a shaft that carries a chuck. The chuck is adjustable to fit a large number of different sized drills.

The preceding suggestions in this series were SIDE-CUTTING PLIERS, SCREW-DRIVERS, THE HYDROMETER, THE BATTERY-TESTING VOLTMETER, THE FILE, THE JACKKNIFE, THE ELECTRIC SOLDERING IRON *and* THE SOCKET WRENCH.



IN THE WORLD'S LABORATORIES

CONDUCTED BY DR. E. E. FREE

Sun Spots May Bother Radio

THE sun is growing spotted again. During the past fall as many as fifteen spots were sometimes visible at one time and some of these spots were more than twenty thousand miles in diameter. Such spots are believed to be evidences of great storms on the sun. They are invariably accompanied by vast magnetic disturbances, which disturbances frequently reach the earth and manifest themselves by alterations in the direction of the magnetic compass, by strong stray currents in telegraph lines and the like.

The spottedness of the sun is known to vary according to a more or less regular cycle with a period of approximately eleven years. The minimum of this sun-spot cycle was passed in 1923 and the number and activity of the spots are now increasing. A recent newspaper interview with Dr. J. A. Fleming, of the Department of Terrestrial Magnetism of the Carnegie Institution of Washington,* warns the public to expect magnetic disturbances whenever the number of sun spots is great. It is probable that the effects of the sun spots on the earth include, also, a share in the creation of static, so we may perhaps expect more static this year than last. Possibly there will be a maximum of static, coinciding with the maximum of sun-spot activity which is due in 1929.

Super-power and Fading

LAST summer's tests of super-power broadcasting, culminating in the alternative transmissions from WGY on fifty kilowatts and on ordinary power, have definitely established two conclusions. First, super-power does not cure fading; many observers reporting that the fading was quite as noticeable on the high power as on the low. Second, the degree of interference on the high power was not noticeably greater than on the low, except, of course, in the immediate vicinity of the station.*

These conclusions seem to have surprised many of the listeners, although there is no reason for such surprise. Both results are quite in accord with the best present-day theories of radio wave propagation. Fading is believed to be due to atmospheric phenomena, mainly the existence and movement of areas of different ionization in the upper air. Such effects ought to apply equally to a wave of any power, so long as its wavelength is unaltered. Similarly with interference, the intensity of any wave falls off so rapidly with increasing distance from the transmitter that a "blanketing" effect from a super-power station would not be expected to extend more than a very few miles from the antenna. On the other hand, the distance range at which a station is audible above the static level ought to be approximately proportional to the power used, and this seems to have been the case with last summer's tests. The continued tests made since then and which are still in progress will lead, doubtless, to still more exact information.

Up and Down Movement of the Heaviside Layer

THAT the famous Heaviside Layer, instead of being a part of the atmosphere lying at a reasonably constant height above the earth's surface, is really located at an extremely variable height, much higher at night than in the daytime and much higher in winter than in summer, is the interesting conclusion derived from the recent high-frequency transmission tests conducted co-operatively by the Radio Division of the Naval Research Laboratory, at Bellevue, D. C., and the American Radio Relay League. Preliminary results, together with a tentative theory of high-frequency wave propagation, are reported by Dr. A. Hoyt Taylor and Dr. E. O. Hulburt, of the Naval laboratory.*

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* Released through Science Service, Washington, D. C., October 20, 1925.

* The results of the tests are reported in a statement from the United States Bureau of Standards, published in the *New York Times* for September 13, 1925, and in the *General Electric Review* (Schenectady, N. Y.), vol. 28, page 720 (October, 1925). Some additional data released by the engineers of WGY were published in the *Radio Section* of the *New York Herald-Tribune* for October 4, 1925.

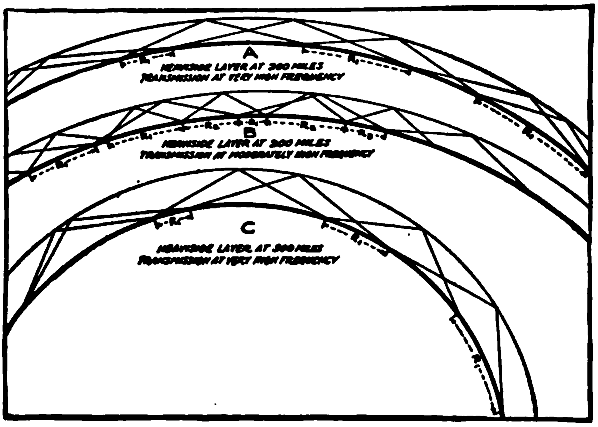
Newspaper accounts, released by Secretary Wilbur, of the Navy, on August 19, 1925, and printed in full in the *New York Times* of August 20, 1925, as well as in other newspapers, referred to the experiments as proving the existence of a "radio roof" around the world. Of course, the experiments prove nothing of the sort. In so far as a "radio roof" exists it is merely another name for the well-known Heaviside Layer. The experiments are, however, of very real importance and, presumably, Dr. Taylor and Dr. Hulburt were not responsible for the newspaper accounts.

By "high-frequency" waves Dr. Taylor and Dr. Hulburt mean the short-wavelength waves, below 100 meters, which are now coming rapidly into use. The tests involved waves from longer than this 100-meter limit down to some as short as 18 meters. The theory developed is essentially an extension of the ionization hypotheses elaborated recently by Appleton, Nichols and Schelleng, Alexanderson and others.† The new contributions of the present paper are essentially two. First is the evidence for the upward and downward movement of the Heaviside Layer from time to time. Second, there is evidence and an explanation concerning the interesting phenomenon of "skipped distance" with these shorter waves.

Radio experts no longer regard the Heaviside Layer as any mirror-like thing which actually reflects the radio waves. It is merely a layer of the air, well up in the atmosphere, in which layer the number of ionized air atoms is unusually high. These ions, you remember, are merely atoms of oxygen or nitrogen or other gases which have lost one electron each, so that the atom comes to possess a positive electric charge. At the same time the lost electrons are set free, so that the space in the Heaviside region contains a relatively large number of loose negative electrons as well as a relatively large number of positive ions. These ions and electrons bend the radio waves, so that a wave ascending from a transmitting station into the upper atmosphere tends to be bent downward when it enters the Heaviside region. If it is bent sufficiently it may even return to the surface of the earth.

It is this bending, Dr. Taylor and Dr. Hulburt believe, which accounts for the phenomenon of "skipped distance," the frequently-repeated observation that short radio waves are perceptible close to the transmitter and also far away, but not in an intermediate zone. The waves perceived far away are reflected waves, returned to the earth's surface from the Heaviside Layer. In certain instances it is possible, they think, for a back-and-forth reflection between the earth and the Heaviside Layer to be repeated several times, so that the transmitting station will be surrounded by successive circular zones of reception and of silence.

These phenomena were already known, more or less clearly, with the longer waves commonly used in broadcasting. By testing them with shorter waves it has been possible to formulate mathematical relations between the width of the "skipped distance" band, the wavelength and the height and properties of the supposed ionized zone in the Heaviside region. Tests made on different short wavelengths showed differences in the width and position of the "skipped distance" band. These results varied, also, with the hour of the day and with the season. Hence the possibility of reaching conclusions as to the different heights of the ionized region at different times.


A
HEAVISIDE LAYER AT 300 MILES
TRANSMISSION AT VERY HIGH FREQUENCY
B
HEAVISIDE LAYER AT 200 MILES
TRANSMISSION AT MODERATELY HIGH FREQUENCY
C
HEAVISIDE LAYER AT 300 MILES
TRANSMISSION AT VERY HIGH FREQUENCY

Reproduced from *QST*

REPEATED REFLECTIONS FROM THE HEAVISIDE LAYER

Rays of radio waves from a short-wavelength transmitter may be reflected back and forth between the Heaviside Layer and the ground, thus producing successive bands of interference and non-interference. These bands vary with the average height of the Heaviside region.

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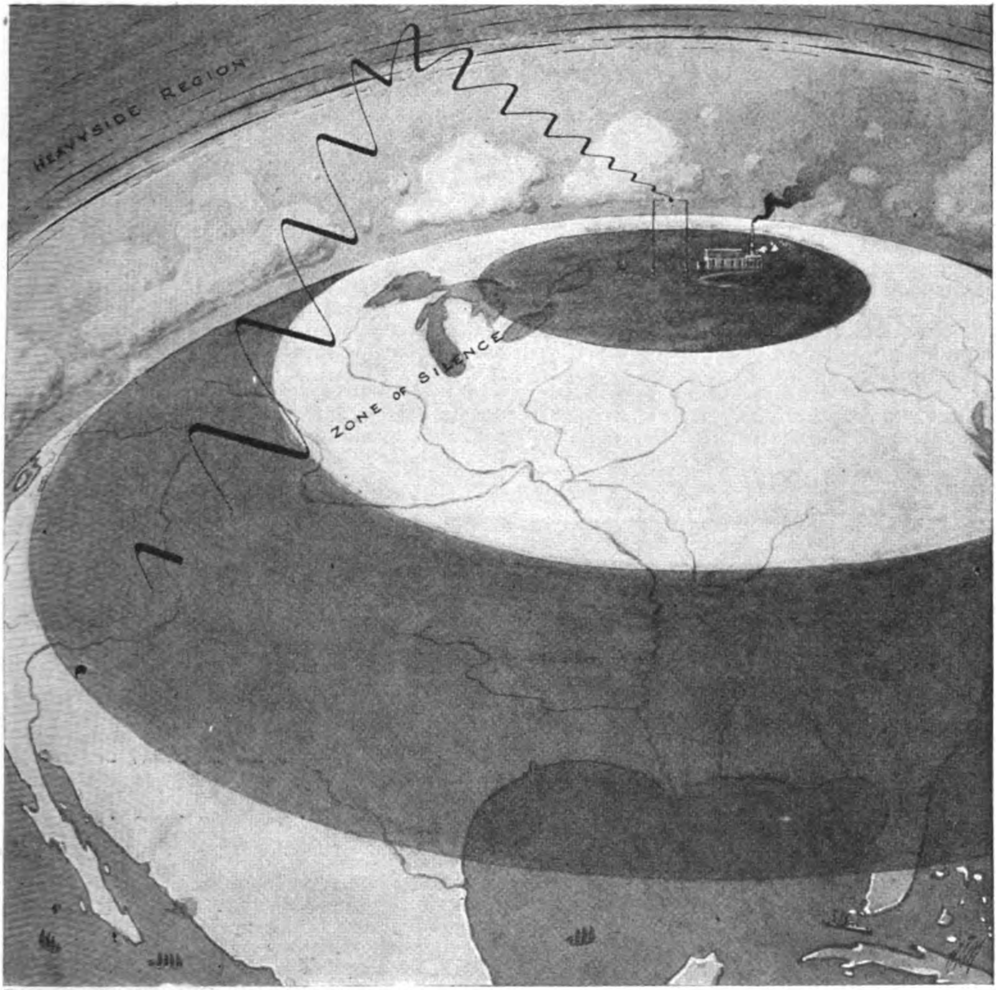
* "Wave Propagation at High Frequencies," by A. Hoyt Taylor and E. O. Hulburt. *QST* (Hartford, Conn.), vol. 9, number 10, pages 12–21 (October, 1925). The substance of the paper was read before the International Convention of the American Radio Relay League, at Chicago, last summer. A brief abstract of the theoretical results, by Dr. Taylor and Dr. Hulburt, appeared in *Science* (Lancaster, Pa.), vol. 62, pages 183–184 (August 21, 1925).

† For a general account of these theories see "How the Air Affects Radio," Popular Radio, vol. 8, pages 199–206 (September, 1925).



From a drawing for POPULAR RADIO by Arthur Merrick

HOW THE HEAVISIDE LAYER CAN CAUSE ZONES OF SILENCE

Close to the transmitter there is a zone in which the signal is heard by the direct path. At a little greater distance these direct waves are so absorbed as to be inaudible in ordinary receivers. At a still greater distance a wave reflected from the Heaviside Layer is picked up. The transmission may be received clearly in this outer zone, shown by shading on the map, although no signal is detected in the intermediate zone of silence.

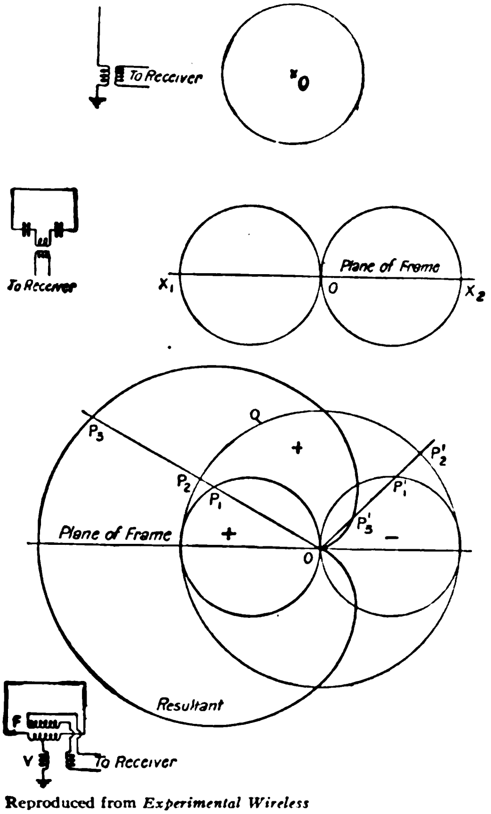
This height varies, Dr. Taylor and Dr. Hulburt believe, between limits which may be as wide as 500 miles and 100 miles above the earth's surface. Sunlight increases ionization in the lower air, thus lowering the position of the Heaviside region. This is why the Layer is lower in the daytime than at night.

If information concerning the propagation of radio waves in the upper and lower levels of the atmosphere continues to accumulate for a few months more as rapidly as it has during the past year we will be in position soon to write a complete theory of radio transmission for all wavelengths, all hours and all seasons; a theory which will take account of all our present mysteries of fading, dead spots and the like. And in this investigation the short waves below 100 meters are proving, as predicted long ago by POPULAR RADIO to be the most effective tool which radio science has yet obtained.

Using Two Antennas for Directional Reception

THERE can be little doubt that one of the features of the perfect system of radio reception—if we ever obtain such a system—will be the possibility of directional reception; a receiver which will receive with full strength the waves arriving from one direction while not receiving waves from any other direction. There would be two advantages in this. One is the easy elimination of interference from other transmitting stations of nearly the same wavelength. The other and more important advantage is the substantial elimination of static. As was pointed out by Professor E. M. Terry over a year ago,* most of the static comes from certain limited points of the compass. If a receiver can be directed to avoid these static sources the reception will be substantially clearer.

That certain types of antennas possess directional properties has been known since the very beginnings of radio. It has long been known, too, that a system of two antennas, connected to the same receiving circuit, may be made to take on a high degree of directional sensitivity. But practical application has lagged. Professor Terry used two antennas in his directional static work just quoted. Also, Mr. H. T. Friis of the Bell Telephone Laboratories, reported recently an ingenious system of attaching two loop antennas to a movable frame, so that the plane containing the two loops could be rotated to obtain a directional effect.† But the most extensive experiments on the two-antenna system—also called the "spaced antenna" or "spaced aerial" system—that have come to light are those conducted by the Marconi Company, in England, under the direction of the well-known radio engineer Mr. C. S. Franklin. With interruptions, these experiments have been in progress since 1913. Certain features of the results, and especially a method of recording and evaluating them, are described in a recent article by Mr. E. Green.‡



Reproduced from *Experimental Wireless*

POLAR DIAGRAMS FOR RECEIVING ANTENNAS

The top diagram shows that a vertical wire receives equally well from all directions. The middle diagram shows the two-direction reception of a loop. The bottom diagram shows the combined reception of a loop and a wire, the heart-shaped curve indicating the combination of the other two.

A simple vertical antenna of the usual type has almost no directional properties; waves from all directions are received almost equally well. An ordinary closed loop antenna has a certain degree of directional response. Its sensitivity is substantially higher for waves coming from either of the two opposite directions in the plane of the loop than for waves at right angles to these. A combination of a vertical antenna and a loop can be so arranged that the system as a whole has unidirectional properties; that is, it receives best from one of the directions in the plane of the loop and almost not at all from the opposite direction. It was such a combination which was used by Professor Terry.

Instead of this combination of a vertical antenna and a loop, two loops may be used. The distance between these loops may be varied, being adjusted to a known fraction of the wavelength being received, usually one-sixth. The relative pick-up of the two loops may be varied, by altering the sizes of the loops or otherwise. The position of the plane of the two loops may be varied by revolving them around a common center, as was done by Mr. Friis. The individual planes of the two loops may be altered by rotating them individually, as is done for the single receiving loop of the radio compass. Finally, the phase-angle of the received waves from the two antennas may be altered by a phase-changer, thus making the two waves any desired degree out of phase with each other.

It is obvious that these manifold possibilities of varying the relation of the two antennas to each other put into the hands of the radio engineer a large number of different reception conditions. Many of these have been worked out in the English experiments. Some have been found quite useful in practice; especially, it appears, a combination of two loops each of which can be rotated independently about its own vertical axis.

For any such system it is possible to construct what is called a polar diagram, which is a chart showing just how the reception characteristics of the antenna system vary with direction. Some of these diagrams are reproduced herewith. They may be thought of as constructed by drawing outward in each direction from the

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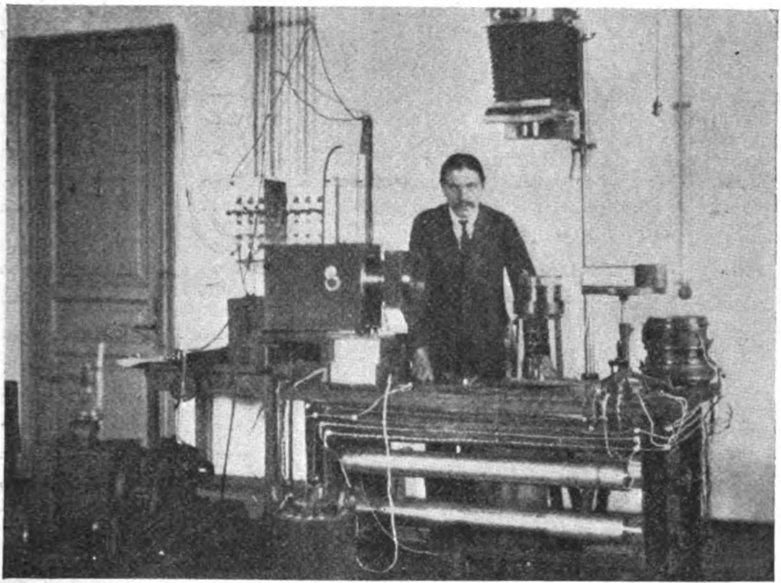
* "Tracing Static to Its Lair," by Earle M. Terry, POPULAR RADIO, vol. 6, pages 342-349 (October, 1924).

† "New Antenna System Reduces Static," this Department of POPULAR RADIO, September, 1925, pages 280-281.

‡ "The Polar Curves of Reception for Spaced Aerial Systems," by E. Green. *Experimental Wireless and The Wireless Engineer* (London), vol. 2, pages 828–837 (October, 1925.).



From a photograph made especially for POPULAR RADIO

MEASURING THE SHORTEST ETHER WAVES FROM RADIUM

With this apparatus, Professor Skobeltzyn, of Leningrad, has measured the effective wavelength of ether waves so short that over one hundred trillions of them are necessary to equal the length of one ordinary radio wave. The rays are used to set free electrons in the chamber just at Professor Skobeltzyn's left and the paths of these electrons in a magnetic field are photographed.

point of reception, a line the length of which is proportional to the intensity of reception in that direction. The polar curves reproduced are then constructed by connecting the outer ends of these directed lines. While the use of these polar diagrams is by no means new in radio engineering, the present paper of Mr. Green is the most comprehensive account which has appeared so far on the use and construction of such diagrams for two-antenna reception systems.

Measuring the Shortest Ether Waves

THE shortest ether waves so far detected by any method are the so-called gamma rays given off by radium and other radioactive materials. These rays are still shorter than the waves of the X rays, although the two ranges overlap somewhat; the shortest X rays produced from X-ray tubes being shorter than some of the longer gamma rays from radium. The shortest gamma rays are, however, substantially shorter than any other known form of radiation. They are believed to have a wavelength of only one five-hundred-billionth of a meter.

These waves are less than one hundred-thousandth of the wavelength of the shortest waves of visible light. As compared with radio waves the discrepancy is still greater. In the length of one ordinary broadcasting wave 300 meters long, there would be approximately 150,000 billions of these shortest gamma-ray waves. Imagine yourself walking from New York to San Francisco. You would have to take some seven million steps. Now imagine an ant walking the same distance. He would take many more steps. But if one of the ant's steps corresponded to one of the shortest ether waves and if he had to walk the length of one ordinary broadcasting wave, his journey would last not merely from New York to San Francisco but fifty times around the earth. So tremendous is the difference between our familiar radio waves and these shortest ether waves which scientists get from radium.

The gamma rays are far too short to be measured by any of the methods used for measuring the wavelengths of radio waves or of light. They are too short, even, to be measured by the crystal methods used to measure X rays. The gamma rays must be studied by indirect methods. One of the most successful of these methods has been described recently by Professor D. Skobeltzyn of the Department of Physics at the Polytechnic Institute of Leningrad, Russia.* As several investigators have done before him, Professor Skobeltzyn makes use of the fact that when the gamma rays strike against matter they sometimes set free electrons, just as light rays do in the photoelectric cell.

The speed of these freed electrons depends, it is believed, on the wavelength of the gamma rays which called them forth. Accordingly, Professor Skobeltzyn exposes these freed electrons to a magnetic field and measures the degree to which this field bends their paths. From this he deduces their speeds, and thence the wavelength of the gamma rays which freed them. By this method he reaches the wavelength of one five-hundred-billionth of a meter already mentioned, a value which accords quite well with estimates of the wavelength of these shortest waves made by other experimenters using different methods.

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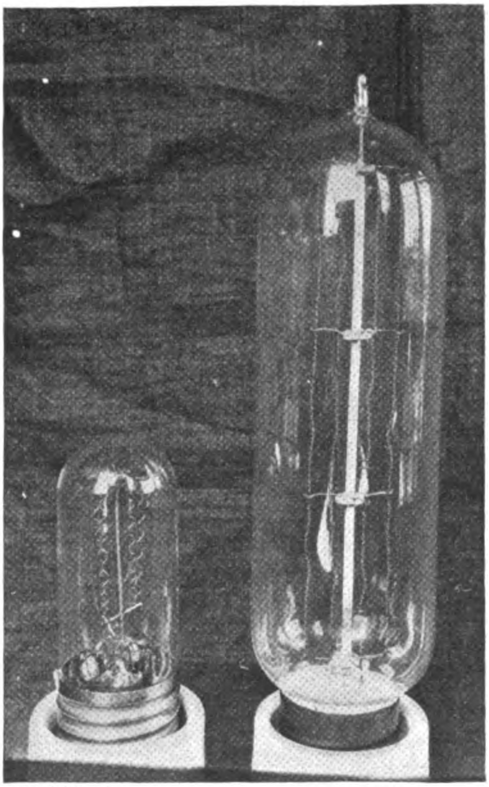
* "The Effective Wavelength of Gamma Rays," by D. Skobeltzyn. *Nature* (London), vol. 116, pages 206-207 (August 8, 1925).

Hydrogen Atoms Operate Useful Accessory

A SCIENTIFIC device which deserves more attention from radio experimenters than it has yet received is the "ballast resistor," an instrument which serves to hold an electric current approximately constant in spite of a considerable variation of the impressed voltage. Suppose, for example, that you wish to charge a storage battery at a constant rate from a power main the voltage of which is quite variable. A ballast resistor will help you to do it. Suppose that you wish to operate an electric lamp at constant intensity in spite of some up or down variations of the voltage. Here, too, a ballast resistor will help. The device operates, in fact, like an electric governor, keeping the current in a circuit constant much as an engine governor keeps the flywheel at a constant speed even though the steam pressure may vary.



General Electric

TWO BALLAST RESISTORS

Both consist of iron wire in an atmosphere of hydrogen. In one the iron filament is coiled, in the other it is merely crinkled. It dare not be drawn tight because of its expansion and contraction with temperature.

The ballast resistor consists of an iron wire in an atmosphere of hydrogen. Its peculiar properties depend on the relations of the iron and the hydrogen, respectively, to the temperature of the wire. As current passes through the wire the wire becomes hotter, just as any conductor will do. This change of temperature changes the electric resistance of the wire, which is also something that happens with the majority of conductors. In the case of iron wire, it happens that a rise of temperature increases the resistance (at ordinary temperature ranges) so that relatively less current will flow. All this is quite usual. Wires of most metals behave in the same way. The peculiarities come in with the hydrogen.

A hot wire in an atmosphere of any gas loses heat to the gas. Gas atoms hit against the wire, acquire some additional energy from it and move away. This cools the wire. The rate of this cooling depends on the nature of the gas atoms, on the gas pressure and on the difference of temperature between the wire and the gas. In the ballast resistor the hydrogen atoms behave in this same way. When current is passing the iron wire is hot. The hydrogen atoms cool it, removing the heat produced continually by the electric current.

Now suppose that the voltage applied to the iron wire increases. Momentarily more current will flow. This will make the wire a little hotter. Two things then happen. First, the resistance of the wire increases, since it has become a little hotter. At the same time, the amount of heat lost from the wire to the hydrogen atoms increases, thus slightly cooling the wire. By a proper choice of the size and length of the iron wire and of the pressure of hydrogen in the tube, it is possible so to adjust these two changes that the increase in the resistance of the wire just compensates for the increase in the voltage, thus passing the same current as before.

Ballast resistors must be designed, of course, for the particular current and voltage-range on which they are desired to operate. Mr. H. A. Jones, of the Research Laboratory of the General Electric Company, has computed recently the necessary formulas and tables. Experimenters desiring to make use of the device will find full and practical information in Mr. Jones' paper.*

An Electrolytic Theory of Crystal Detectors

THE action of the familiar crystal detector is still a good deal of a mystery. What happens is that the alternating current in the radio-frequency part of a receiver passes the crystal in one direction, but not in the other. The crystal acts as a one-way valve for the

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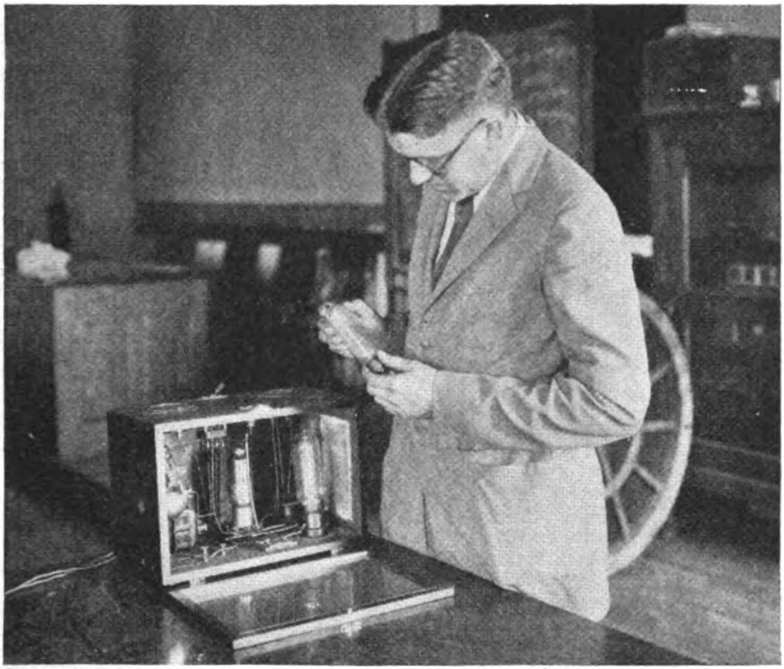
* "The Ballast Resistor in Practice," by H. A. Jones. *General Electric Review* (Schenectady, N. Y.), vol. 28, pages 329–335 (May, 1925), and "The Theory and Design of Ballast Resistors," same author and publication, pages 650–659 (September, 1925).



General Electric

THE CONSTANT-CURRENT BALLAST RESISTOR

Mr. H. A. Jones is holding one of the ballast resistor tubes in his hand. Another is inserted in the set-up on the table. One of these resistor tubes will hold the current through it at an approximately constant value in spite of considerable variations of the impressed voltage.

electrons. Everyone knows this. What no one knows is why the crystal acts this way. Why can electrons pass from cat-whisker to crystal (or the reverse) but not in the opposite direction?

There have been many theories for this rectifying action of the crystal. Some of them have been noted in this department. The latest —and in many ways the most plausible—has been proposed recently by Mr. Alfred Clive James of East London College, London, England.*

It is an electrolytic theory, which means that it involves the same general kind of electrochemical action which happens when you charge a storage battery or when you pass an electric current through acidified water. When you thus "electrolyze" the water the water is broken up. Oxygen atoms appear at one of the electric terminals; hydrogen atoms appear at the other terminal. Now a crystal consists, for example, of lead sulphide, which is galena. It contains lead atoms and sulphur atoms. What happens, Mr. James thinks, is that the current passing through the crystal drives the lead atoms and the sulphur atoms apart from each other, more or less. In a similar way, the current in the water drives apart the atoms of hydrogen and of oxygen.

The lead atoms accumulate, he believes, at the point where the cat-whisker touches the crystal. These atoms accumulate very quickly, just as the bubbles of the gases appear instantaneously when the current is turned through water. They may be accumulated, in fact, by a single, one-direction pulse of the current. During this one pulse more and more lead atoms continue to accumulate in contact with the others. The spot of metallic lead thus formed at the crystal surface makes an easy path for the electrons into or out of the crystal.

Suppose, now, that the direction of the current changes. The lead atoms would then tend to go in the other direction. But a lot of lead atoms have become attached already to the cat-whisker. These must be removed. In a sense, they must be "dissolved" again in the main mass of the crystal, just as a part of the material on the active plates of a storage battery is dissolved while the battery is being discharged. This removal of the lead atoms absorbs some of the energy of that pulse of the current. At the same time, some sulphur atoms are left at the point of contact. These are non-conducting. No current gets through.

When the current reverses once more the lead atoms again accumulate in contact with the cat-whisker, the current passes, and the cycle begins all over again.

This theory involves the assumption that the metal atoms in a crystal of galena are able to move around, more or less freely, through

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*"The Rectification of Alternating Currents by Crystals," by Alfred Clive James. *The Philosophical Magazine* (London), Series 6, vol. 49, Pages 681-695 (April, 1925).

the meshes of a fixed network of sulphur atoms. We do not know enough about the inside structure of galena crystals to say definitely whether or not this is true, but there seems to be no important evidence against it. Also, it provides, for the first time, a possible mechanism to explain the mysterious occurrence of sensitive and insensitive spots on the same crystal surface.

In crystals of argentite, which is sulphide of silver instead of sulphite of lead, the movable atoms are those of silver. These silver atoms accumulate and dissolve at the contact point, just as the lead atoms do in galena. The sulphur atoms are fixed, as before. Other crystals, such as carborundum, are thought of as acting in the same general way, some electrolytic change inside the crystal being responsible for the rectifying action.

So far, all this has little practical importance. But if it does prove that Mr. James has put his finger on the vital clue to crystal rectification we will doubtless be able soon to improve the utilization of crystals in practical radio. Even now, it is notorious that crystal detection is more nearly distortionless than any other procedure which we know how to use. Perhaps a knowledge of how the atoms act inside crystals will yet bring the crystal back to an honored place in radio.

One-way Propagation of Radio Waves

One of the puzzles of radio has long been the apparent fact that transmission may be possible in an east-to-west direction (or vice versa) when it is not possible in the opposite direction between the same two stations. This has seemed very surprising. Radio waves are supposed to pass through the ether. If at the same instant and with the same power, a station in England can reach one in the United States but cannot hear the precisely similar signal moving in the opposite direction, it looks as though the ether were a one-way street, a supposition which the physicists have never been willing to entertain. Yet many instances of such apparent one-way transmission have been observed in the past five or six years.

Captain T. L. Eckersley, of the British Marconi Company, now comes to the rescue with a suggestion of two ways in which such a difference between wave propagation in opposite directions might be produced.* Both ways depend on the assumption that there may exist in the atmosphere more or less separate clouds of "slabs" of ionized air, an assumption already made, years ago, by Dr. Reginald A. Fessenden.†

If these "slabs" of ions are in motion, either vertically or in a direction parallel to the latitude, there will be reactions on the passing radio waves, which reactions are unidirectional and may oppose either the east-to-west wave or the west-to-east one, while at the same time favoring the propagation in the reverse direction. Captain Eckersley analyzes briefly the mathematical and physical conditions necessary for such a one-way barrier to the waves.

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* "Non-Reversible Transmission," by T. L. Eckersley. *Nature* (London), vol. 116, pages 466–467 (September 26, 1925).

† "Wireless Telegraphy," by Reginald A. Fessenden. *The Electrical Review* (London), vol. 58, pages 744–746 (May 11, 1906) and pages 788–789 (May 18, 1906). See Dr. Fessenden's article, "How Ether Waves Really Move," Popular Radio, vol. 4, pages 337–346 (November, 1923).

General Electric

HE FINDS SOMETHING INTERESTING IN MATTER

One of the features of the meeting of the American Chemical Society, at Los Angeles, last summer, was an address by Dr. Willis R. Whitney, of the General Electric Company on "Matter—Is There Anything in It?" By a series of ingenious and spectacular demonstrations Dr. Whitney showed the chemists some of the remarkable properties of the tiny electrons and protons which make up the atoms of matter and which are so important in radio.

WHAT'S NEW IN RADIO APPARATUS

This *department is conducted by* **Popular Radio Laboratory** *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*

A neat binding post that is easy to operate.

A SPRING BINDING POST

Name of instrument: Binding post.

Description: A small, neat binding post that contains a spring top, which when pushed in opens the hole in the side to which the wire may be inserted. Upon releasing the pressure of the spring by taking the finger off the binding post a firm solid connection is made. Equipped with circular name plates that designate what the binding post is to be used for. Neatly made and nickel plated.

Usage: In combination with a home-built receiving set for making connections to the batteries and the antenna and ground.

Outstanding features: Ease of operation. Good contact. Neat appearance.

(Further details furnished on request.)

A TUBE REJUVENATOR

Name of instrument: Tube rejuvenator.

Description: This piece of apparatus is contained in a metal cabinet with a black crystalline finish. The apparatus is equipped with a long extension cord for fastening to the 110-volt 60-cycle lighting lines. It will reactivate both the small and large thoriated filament tubes of the 199 or 201-a type. It is equipped with a lever which changes connections in the interior for producing the high current for flashing the filament, the medium current for maximum reactivation of the filament and the normal current for lighting the filament during test. When this lever is moved to the extreme left a reading on the meter is obtained that gives an indication of the filament emission, so that the operator may determine just when his tube is fully reactivated.

Usage: As an accessory for radio set owners in getting their tubes in good condition.

Outstanding features: Compactness. Efficiency. Ease of operation. Equipped with a meter.

(Further details furnished on request.)

A compact device for making new tubes out of old ones; it operates simply and efficiently.

A TRANSFORMER FOR THE NEW RAYTHEON TUBE

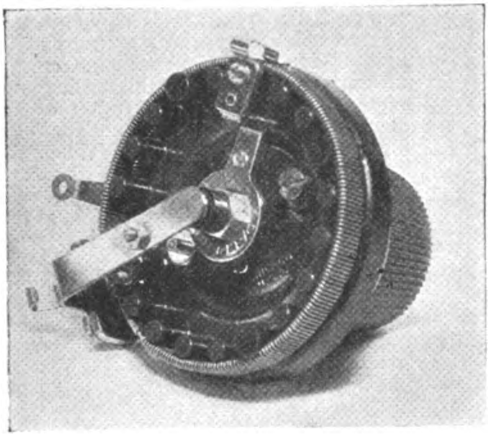
Name of instrument: Step-up transformer.

Description: This transformer consists of a primary winding for operation on 110 volts 60 cycles alternating current with a split secondary winding which is statically shielded from the primary by means of a copper shield brought out to a separate binding post. This secondary supplies the high voltage alternating current to each side of the full-wave rectifying tube, with which the transformer is designed to be used. The instrument is mounted in a black enamel case with an extension cord running to the lighting socket. The case is so designed that a free circulation of air is obtained.

Usage: As a transformer for supplying the necessary energy to the Raytheon Plate Supply Unit.

Outstanding features: Neat in appearance. Sturdy in construction. Easy to install.

(Further details furnished on request.)



This rheostat will not get hot.

A TWIN VARIABLE CONDENSER

Name of instrument: Double variable condenser.

Description: This unit is unique in design by reason of the employment of two sets of rotor plates on a single shaft and two insulated sets of stators. It may be used for tuning two stages of radio-frequency amplification simultaneously by means of a single knob or for other uses where a tandem condenser is found. The workmanship of this unit is of the same high standard as other instruments by the same maker.

Usage: In any radio-frequency circuit for tuning.

Outstanding features: High efficiency. Compactness. Dual operation. Easy to mount on panel.

(Further details furnished on request.)

A well-made plate-supply transformer.

A NEW RHEOSTAT

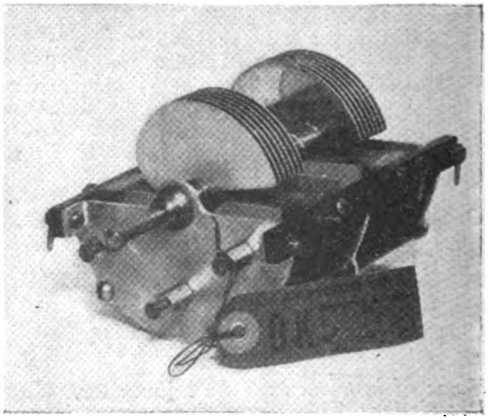
Name of instrument: Rheostat.

Description: A novel means of supporting the rheostat winding is used in this device; it is bent around a series of insulated plugs made in one piece with the bakelite base of the instrument. This gives the resistance element a large radiation of heat and prevents burning out the coil or damaging the insulation upon which the resistance wire is wound. A novel means of variable contact is made in which the flexible contactor runs around the outside of the element. The instrument is equipped with soldering lugs.

Usage: In any receiver for controlling the filament current of vacuum tubes.

Outstanding features: Accurate workmanship. Good contact. High radiation of heat. Smooth action. Neat appearance.

(Further details furnished on request.)



Single-control may be accomplished with this condenser.

A UNIVERSAL TUBE SOCKET

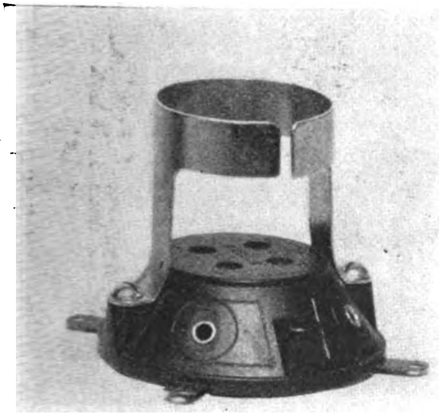
Name of instrument: Vacuum-tube socket.

Description: This new socket is available for use with all of the new UX type of tubes, new WD type of tubes and for the older UV-201-a types. It is fitted with a new special contact that is one piece throughout and including the soldering lug. A metal support is fastened with two screws to the top of the socket for holding some of the tubes in rigid upright position.

Usage: In a radio receiver for mounting vacuum tubes.

Outstanding features: Compactness. Fits all standard types of tubes except the old 199. Neat in appearance. Low capacity. Good contact.

(Further details furnished on request.)



A socket for all standard tubes.

A WELL INSULATED CONNECTOR

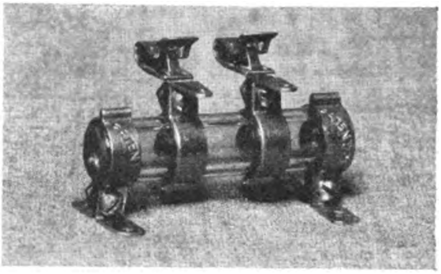
Name of instrument: Connection block.

Description: This device consists of a cylinder of glass supported by two metal clamps—one at each end. Two other metal terminals are provided—insulated from each other and from the end clamps by means of the glass cylinder. These contain Fahnestock clips as well as soldering lugs to which the lead wires may be directly connected.

Usage: In the experimental laboratory as terminals for batteries or generators.

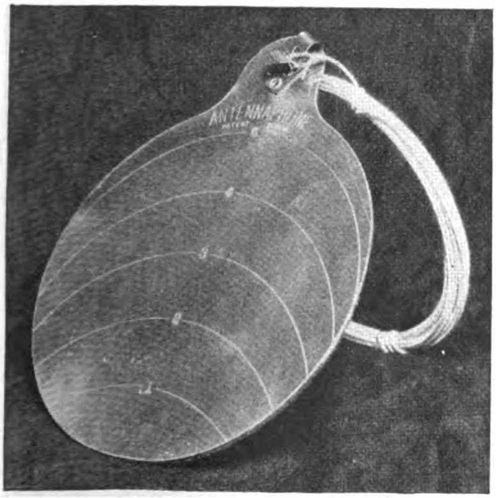
Outstanding features: Good insulation. Compactness. Ease of installation and attachment.

(Further details furnished on request.)



A small connection block in which the terminals are well insulated from each other and from everything else by means of a glass tube.

A NOVEL ANTENNA TERMINAL



***A novel device** to connect the telephone wires to the set as an antenna.*

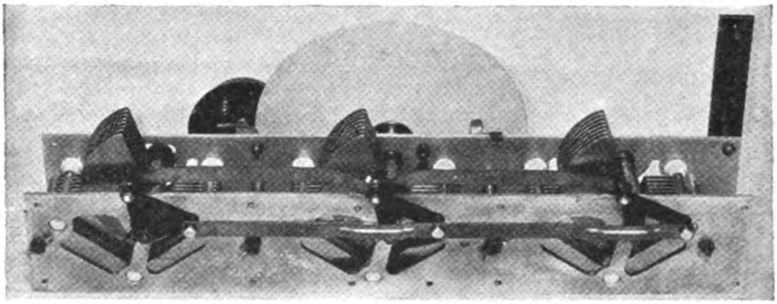
Name of instrument: Antenna connection.

Description: This device is a small disc of metal of about the same diameter as the bottom of a telephone stand. It is equipped with a Fahnestock binding post and a length of wire which may be attached to the antenna post on the receiving set. By merely placing the telephone desk stand on it, the felt bottom of the telephone stand acts as an insulator and as the dielectric of a small condenser of which the metal plate is one terminal and the desk stand is the other terminal. In this way, the radio signals that are collected by the telephone wires may be transferred to the receiving set. The signal strength obtained with an attachment of this kind is somewhat dependent upon the local telephone circuit, but a sensitive set should give results in nearly all cases.

Usage: In connection with a telephone line and a radio receiving set as a pick-up device.

Outstanding features: Simplicity. Compactness. Easily installed.

(Further details furnished on request.)



Three condensers harnessed together to give you single-control with a dial calibrated in wavelength.

A UNIT CONTROL TRIPLE CONDENSER

Name of instrument: Triple Condenser Unit.

Description: In this novel unit three condensers are mounted and controlled by a single knob which acts through friction through the large solenoid disc. The disc is set on the rotor shaft of the middle condenser and a novel cam arrangement turns the two outside rotor units of the condensers. The dial is calibrated in wavelength and when the unit is used with the proper coils any wavelength may be tuned in by simply turning the single knob so that the reading appears at the indicator.

Usage: In a receiving set for tuning a two-stage radio-frequency amplifier with a single knob.

Outstanding features: Single control. Uniform capacity settings. Efficiency. Direct wavelength calibration. Fine workmanship.

(Further details furnished on request.)

A STORAGE BATTERY THAT CHARGES ITSELF

Name of instrument: Storage battery with self-contained trickle charger.

Description: This "A" supply unit is made in two sizes for either 4 or 6 volts operation and contains either two or three cells respectively. It also contains a trickle charger that keeps the cells always in operating condition. It is equipped with binding posts for connection to the set and a switch that is used for connecting the batteries through either the charger or to the receiver. A plug is furnished for connecting to the socket of the ordinary alternating current lighting lines. By this arrangement a small switch may be thrown to either one of two positions which provide the set with filament current, or charge the batteries. In this way, the battery is being continuously charged at all times at a very slow rate except when it is furnishing power to the receiving set.

Usage: In connection with a receiving set for supplying filament current.

Outstanding features: Automatic in operation. Reliable. Keeps batteries always in good condition. Relieves the set owner from worries about keeping battery charged. Neat in appearance.

(Further details furnished on request.)

Simply throw a switch to connect this battery to your receiving set; then throw it back again and it becomes fully charged while not in use.

Apparatus Approved by Popular Radio

This list of apparatus approved by the POPULAR RADIO LABORATORY will be continued as a part of the WHAT'S NEW IN RADIO APPARATUS department until all instruments, parts and complete sets have been included. The listing is alphabetical by manufacturer's name and the installment in this issue includes the letters U through Z.

AUDIO-FREQUENCY AMPLIFIERS

Veby complete 3-stage resistance-coupled amplifier; Veby Radio Co.

AUDIO-FREQUENCY TRANSFORMERS

"United" audio-frequency transformer; United Mfg. & Distributing Co.
Audio-frequency transformer; Louis E. Werts

BATTERIES

RB "B" battery; Universal Battery Co.
U. S. L. radio "A" and "B" batteries; U. S. Light & Heat Corp.
Waterbury "A" battery; Waterbury Battery Co.
Westinghouse crystal case "A," "B" and "C" batteries; Westinghouse Union Battery Co.
"Willard" radio batteries; Willard Storage Battery Co.
Radio "B" battery; Winchester Repeating Arms Co.
"Wizard" "A" and "B" batteries; Wizard Battery Co.
"World" storage "A" and "B" batteries; World Battery Co.

BATTERY CHARGERS AND RECTIFIERS

"Valley" battery charger; Valley Electric Co.

BINDING POSTS

Lettered binding posts; Walnart Electric Mfg. Co.

CRYSTAL DETECTORS

"Cummings" union crystal; Union Radio Elec. Stores, Inc.
"Yellowtip" crystal detector; Wholesale Radio Equip. Co.

DIALS

Micrometer dial; U. S. Tool Co., Inc.
Knobs and dials; Walbert Mfg. Co.
Dial; Walnart Electric Mfg. Co.
"Workrite" E-Z-Tune dial; Workrite Mfg. Co.
Knobs and Dials; Yaxley Mfg. Co.

FIXED CONDENSERS

Fixed condenser; Walnart Electric Mfg. Co.
Fixed condenser; Yaxley Mfg. Co.

GRID-LEAKS AND RESISTANCES

Variable grid resistances; Walnart Electric Mfg. Co.
Royalty variable grid-leak; Wireless Products Corp.
Royalty resistance units; Wireless Products Corp.
Resistance unit; Yaxley Mfg. Co.

HEADPHONES

"Ampl-tone" phones; Union Fabric Co.
"Warren" phones; Warren Radio Phone Mfg. Co.
"Workrite" concert headset; Workrite Mfg. Co.

JACKS

Union tip jack; Union Radio Corp.
Jacks; Yaxley Mfg. Co.

KITS

U-ni-dial kit; Unidial Radio Co.
Super-heterodyne kit; Victoreen Radio, Inc.

LOOPS

Variable radio loop antenna; Werner Radio Mfg. Co.

LOUDSPEAKERS

Black Beauty reproducer; United Radio Corp.
"Utah" phono-speaker; Utah Radio Products Co.
"Van-Le" reproducer; Van-Le Corporation
Professional reproducer; Voluma Products, Inc.
"Moon" loudspeaker; Wilson Utensil Co.
"Windsor" loudspeaker; Windsor Furniture Co.

MISCELLANEOUS ACCESSORIES

Dial adjusters; Union Radio Corp.
Valley clip; Valley Electric Co.
Solder flux and rosin core solder; Valley Forge Chemical Co.
Var Flex tubing; Var Flex Corp.
Var Flex wire core; Var Flex Corp.
"Cross Country" circuit (parts and instructions); Vesco Radio Co.
"Penetrola" (auxiliary unit); Walbert Mfg. Co.
Panelites; Walbert Mfg. Co.
Adjuster; Walnart Electric Mfg. Co.
"Workrite" concertrola; Workrite Mfg. Co.

PANELS

Hard rubber panels; United States Rubber Co.

PHONE PLUGS

G. W. 5-circuit plug; G. E. Walker Co., Inc.
Plug; Yaxley Mfg. Co.

PHONOGRAPH ATTACHMENTS

Ampl-tone loudspeaker unit; Union Fabric Co.

POTENTIOMETERS

Potentiometer; United Scientific Laboratory, Inc.
Potentiometer; Yaxley Mfg. Co.

RADIO CABINETS

De Luxe radio cabinets; Utility Cabinet Co.
Radio cabinet; Whaling Wood Products Co.

RADIO-FREQUENCY TRANSFORMERS

"United" radio-frequency transformer; United Mfg. & Distributing Co.
"Victory" 4-circuit transformer; Victory Radio Co.
"Werner" radio-frequency transformer; Werner Radio Mfg. Co.

RECEIVING SETS

"Unidyne" receiver; United Mfg. & Distributing Co.
U-S-L Broadcast receptor; U-S-L Radio, Inc.
"Radiodyne" receiver; Western Coil & Electrical Co.
"Elf" crystal receiver; Westwyre Co.
Zenith receivers; Zenith Radio Corp.

RHEOSTATS

Rheostat; United Scientific Laboratory, Inc.
"Unity" vernier rheostat; Unity Mfg. Co.
Rheostat; Wilcox Laboratories.
"Workrite" vernier rheostat; Workrite Mfg. Co.
Rheostat; Yaxley Mfg. Co.

SOCKETS AND ADAPTERS

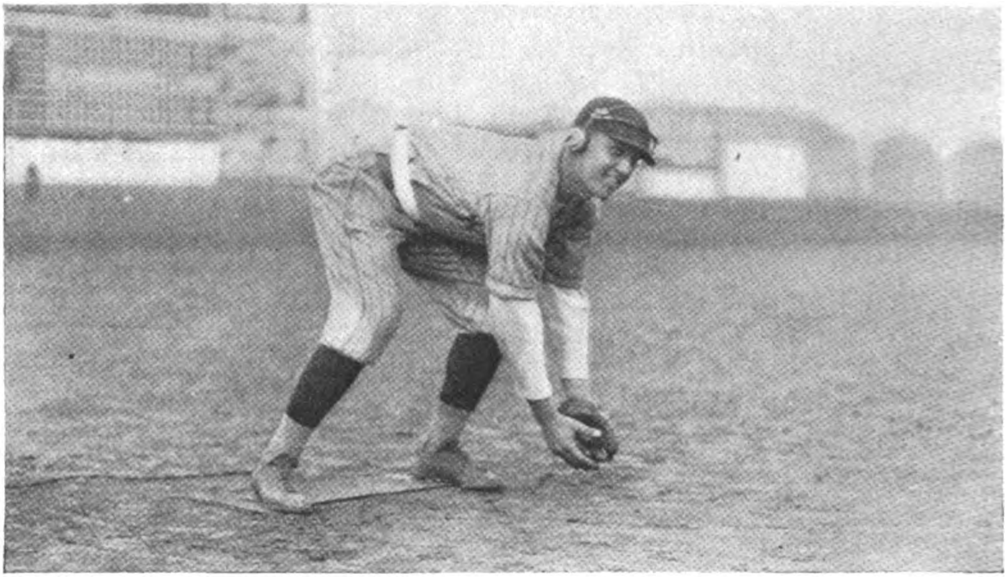
V. T. Socket; Union Radio Corp.
Walbert safety rim socket; Walbert Mfg. Co.
Walnart sockets (bakelite insulation); Walnart Electric Mfg. Co.

SWITCHES

Filament lock switch; Walbert Mfg. Co.
Switch; Walnart Electric Mfg. Co.
Midget battery switch; Yaxley Mfg. Co.
No. 210 Pilot light switch; Yaxley Mfg. Co.

TESTING INSTRUMENTS

Weston panel voltmeter; Weston Electrical Instrument Corp.



Louisville *Courier-Journal*

DUPLICATING THE WORLD'S SERIES BY RADIO

Replaying the innings of world's series baseball games on a field in Louisville, Kentucky, while the games were actually going on in Pittsburg or in Washington was the feat that radio made possible. Two Louisville teams took the part of the big leaguers and duplicated every play within a few minutes after it was made. The players all wore headphones. These were wired to their feet and a connection made through metal discs set in many parts of the field. The broadcast report was picked up by receivers and transmitted to the players who re-enacted what they heard.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

Some Grade-A Broadcasting at Last

THE big-meter waves have washed up a few A-number-one radio-acts since the appearance of our smashing review in the November issue. As a matter of fact, it begins to look as though we might have to take back what we said about the small difference between the summer and winter season. Here we have heard Josef Hoffmann, Olga Samaroff, May Peterson and Louise Homer and Toscha Siedle all within the space of a single month! That's a pretty heavy brand of entertainment after you've grown accustomed to a musical diet consisting chiefly of nothing but homeopathic doses of twenty-nine-cent phonograph records. It's getting so that you cannot tell what radio will do next. One day it is walking down Sixth avenue in a crash suit smoking Cincos and the next day it is swanking down Fifth avenue with a full cutaway, a topper and a fifty-cent straight. You say it with razzberries one day and with a great big bunch of orchids the next.

There is just one little fault that we have found with the Atwater-Kent programs. Not that we wish to put on the elegant air of the snooty connoisseur, for we are perhaps one of the worst listeners that ever fell into applauding with the rest of the pretenders at Carnegie Hall.

It seems to us that these air concerts would be immensely improved with a more brilliant accompaniment for the singing artists. In the concert hall, with its dazzling chandeliers, its smartly dressed women and its gayly decorated walls, there is created an atmosphere that makes the piano sufficient, but that same piano is a pretty drab background in a radio recital. This admission may show us up as being one of the rawest radio critics in the business, but just the samey we feel that Mr. Atwater-Kent would be giving his concerts a full twelve-pound sound by adding a small symphony orchestra. A concert in Carnegie Hall and a concert in the home of J. Whoasis Smith, 567 Plimpton avenue, the Bronx, U. S. A., are two totally different things. In Carnegie Hall it is not difficult to make May Peterson sound like a $3,000-a-night voice with the piano as the only support, but when you lift that voice out of the Hall and place it in the average American home you haven't very much left. It's just like taking the purple spot off the stage mystic.

There is no good reason to say that Mr. McNamee is doing a fine bit of announcing in connection with the Atwater-Kent programs, because he isn't. If Mr. McNamee is not flattering the star he is flattering or patronizing his audience, and if he isn't doing that he is tossing out a literary garden of American Beauties. Still Mr. McNamee is the star announcer of WEAF, and was rushed right from the World's Series to the opening concert of the Atwater-Kent programs. It does seem a bit incongruous that a man should perform so efficiently at baseball, at the ringside, at political conventions, at football and at big league recitals. Either Mr. McNamee is a very keen and widely learned gentleman or he is of just ordinary sophistication and is being badly overworked.

If we had the handling of the Atwater-Kent programs we should engage an announcer with the training and background of—of—.

Just fancy that, we can't think of a soul! Well, we'd save Mr. McNamee for the next World's Series, anyway.

* * *

A Hot Shot from Chicago

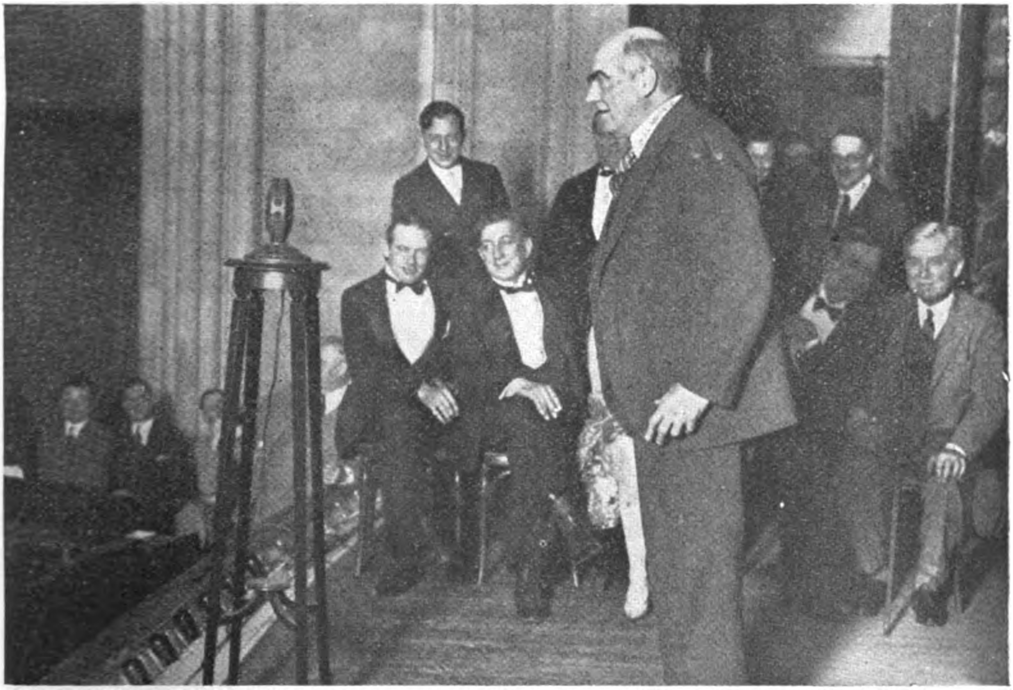
JUST when we are beginning to take seriously the many, many thousands of flattering letters received, along comes a Chicago reader with a mad on.

"Dear Sir:

"Don't take this salutation seriously.

"Beyond a doubt you are of the type that would kick the crutches from under a cripple in a traffic jam. I have been reading with growing disgust and finally with pity your puny efforts at mirth under the section 'The Broadcast Listener.'

"Now for a dose of your own literary effort. Perhaps I can set your warped intellect right regarding broadcasting in the Chicago district. I refer especially to your paragraph 'The Chicago Listeners Strike.' In the first place Chicago is still in the republic and neglecting the 18th Amendment the Constitution is holding sway. A petition from thousands of broad-



Kadel & Herbert

THEATRICAL STARS ENTERTAIN HOSPITAL PATIENTS BY RADIO

A program which was designed for the special benefit of hospital patients, and furnished by many famous stars of the theater, was broadcast recently from the Friars Club in New York. Burr MacIntosh, actor, author and lecturer, is here shown before the microphone in the famous club's quarters.

cast fans has forced the Chicago broadcasting stations to close one night a week. We've a right to our opinion here as well as you in the Empire State. In addition, the Mayor's Radio Commission requested all local stations to close on Monday evening. Many broadcasters took advantage of this by reason of the fact that their stations were located outside the corporation limits. After a good deal of effort, the Radio Broadcast Listener's Association, of which I am *not* a member, succeeded in closing all these stations with one exception. This station is negligible, because it is on too high a frequency and cannot be heard well on the ordinary receiver.

"We'll admit that broadcasting is not yet on the hoity-toity plane you are planning on putting it. There are as many people who like dance music and popular songs as there are those who enjoy highbrow music. I am of the opinion that there is room for every type of music and program. But were we to accept your recommendation, we would degenerate to your type of spineless jellyfish, wanting only one thing and to hell with the others. I have listened to Art Linnick go from one station to another, singing the same song six days a week for one whole summer. Certainly we are entitled to hear the Hotel Nicollet orchestra at Minneapolis or the Hotel Alexandria orchestra at Los Angeles one night a week. As far as I'm concerned they could close every Chicago station seven nights a week and I'd never miss 'em. But there are thousands who would. We are entitled to one night a week to hear what the other fellow is doing. You might reply, 'Get a good set.' Thank you, I have one, but the most selective in the shadow of WIBO, WQJ, WBBM and WEBH would have a sweet time cutting off the dozens of wavelengths on which some energy is being radiated. Thirty-two local broadcasting stations are capable of blanketing the entire broadcast spectrum.

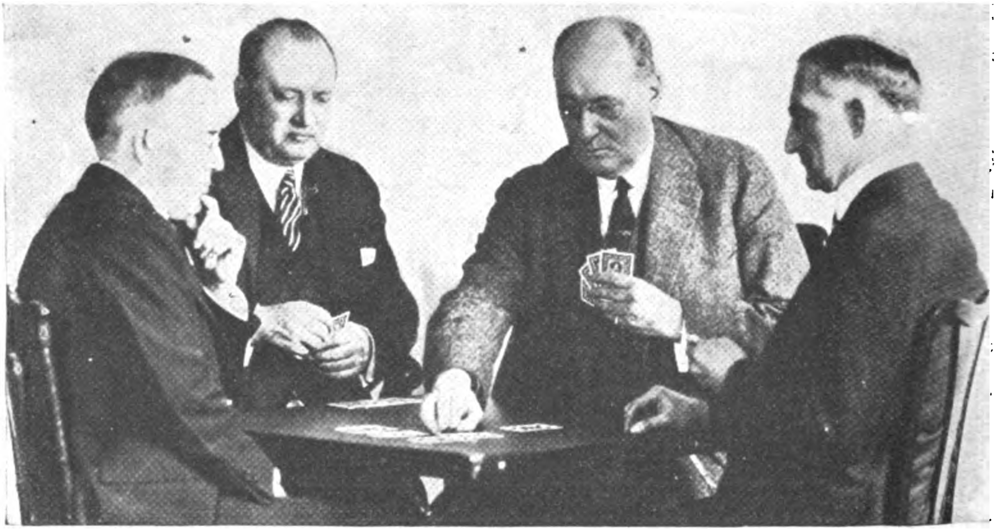
"Believe me sincere,

"H. M. D."

We did feel a little mean and small after reading H. M. D.'s letter, but we walked right out and tossed off a Coca-Cola and came back feeling fine. Part of the next three days we spent trying to think up a funny answer for H. M. D.'s calling us a kicker of crutches from under cripples in traffic jams, but for the life of us we could not think of a thing that had the right kind of a ring to it. We might have told him, however, that we once stood for fifteen minutes on a nickel that a poor old lady had dropped in the post office. There's really no telling what we might do in a traffic jam.

When we came to the part of Mr. H. M. D.'s letter wherein he accuses us of trying to lift broadcasting to a hoity-toity plane we just lost control of ourself and guffawed so that you could hear it all over the place. That is, perhaps, the funniest statement that has ever been made in this department. We had thought up until this time that "our puny efforts at mirth" was one of the most substantial barrels of solid hoke mined in the western hemisphere. Another letter like that and we shall go right up to Carnegie Hall and write a cruel and devastating *critique* on Mr. Walter Damrosch's conducting.

Mr. H. M. D. says "I am of the opinion that there is room for every type of music and program." That either proves that Mr. H. M. D.



BROADCAST-LISTENERS SIT IN ON A BRIDGE GAME WITH EXPERTS

Radio fans recently had a chance to learn the fine points of auction bridge from some of the best-known authorities when games played by E. V. Shepard, W. C. Whitehead, Milton C. Work, and Sidney S. Lenz were broadcast play by play.

Kadel & Herbert

POLITICAL CAMPAIGNERS DISCARD THE "STUMP" FOR THE "MIKE"

Instead of addressing the handful of listeners who can come within range of his voice, the politician of today addresses hundreds of thousands at a time by radio. The political contests of tomorrow will be largely contests for access to broadcasting stations. Here is a peep at the broadcast debate between Governor Smith of New York and Representative Ogden Mills on the eve of Election Day at Buffalo.

is a member of the Kiwanis Club or that he has really given serious thought to this business of broadcasting. It invariably happens that a man doing heavy thinking on the subject of programs eventually comes to the conclusion that America is a racial vegetable stew and that, consequently, its broadcasting must be built upon the principle of a crazy-quilt or a Beloochistan rug.

If you meet us on the street some day muttering strangely and incoherently, you will know that we succumbed to the mental strain of trying to devise a hoity-toity program that will please cosmopolitan America.

Seriously, we shall try to be more tolerant, as Mr. H. M. D. wishes. You know the voice with the smile wins, and we really should have more Kewpie dolls smiling at us from the mantelpiece.

* * *

The Demands of the Society of Authors and Composers

Up until a few months ago we had worked up quite a bit of sympathy for the Society of Authors, Composers and Publishers, but subsequent action of the Society in attempting to extort what would amount to a fee of from $100.00 to $200.00 a day from each broadcaster in the United States, has left us a bit cold and prejudiced. The demands are exorbitant and ridiculous, and they show that the officers of the organization have a very poor head for "figgers." At the rate mentioned, there is not one broadcaster in the country that will be able to meet these demands and, except in isolated cases where broadcasters desire to use special programs, the Society's income from radio will be small enough to carry around in the change pocket of any overcoat.

If the Society would ask a reasonable charge of say $10.00 a day for each broadcaster using its copyright music, its income would be increased by some hundred thousand dollars a year, which would be just so much gravy. Instead of being satisfied with this the Society is setting to the task of gathering in millions from an industry that has been bankrupt since the very day it was born.

* * *

An Atlantic City Fan Breaks Loose

"Dear Sir:

"When one does a good thing it is natural that one likes to know that others appreciate it. Consequently, I am doing something very unusual for me—taking the time and trouble in a very lazy life to congratulate you on your strong editorials. I refer especially to 'Studio Sheiks' and 'Some Pretty Bad Stations.'

"In your next editorial, please comment on these lady-like announcers who try to put such pathos in their voices. It is plainly evident that they are listening to themselves. I refer especially to Clarence Bowden of WOO and Major Bowes of the Capitol. Major Bowes certainly does 'love his little family'—my God!

"You must listen to Clarence tell about the composers of the organ compositions he plays. It is certainly amusing to listen to these fellows with their broad A's and their totally affected pronunciations of various sorts and styles.

"And while I'm all het up and mad, I want to damn this word *ensemble*, which seems to have just been discovered. Orchestra and band are good old-fashioned words and they are exact in their meaning.

"The writer of 'The Broadcast Listener' certainly has courage.

"C. S. D."

(Will Mr. H. M. D. please note?)

* * *

How to Run a Broadcasting Studio

If anybody should ever ask us to manage a broadcasting studio we should immediately post a set of rules and regulations, which, if followed out, would make it the best station in this great big world of ours. After you stop to carefully weigh this boast, it really isn't saying a lot. If you set out to make a better Woolworth Building or a better radio magazine than Popular Radio (advt.) you'd have a pretty hard job on your hands, but the formula for the world's best broadcasting station should be just about as easy as an improvement in circus lemonade.

Rule No. 1. Announcers must refrain from giving even a hint concerning their identification.

Rule No. 2. Any announcer caught using the broad A or making other effort to sound ritzy, will arrange his own appointment with the cashier.

Rule No. 3. Announcers must not use the phrase "and now at this time." Now usually means "at this time." (WJZ-WJY staff please note.)

Rule No. 4. One soprano will be permitted to sing two selections from this studio every third Friday.

Rule No. 5. The equipment of this station is not available to the clergy unless they can relieve their voices of every trace of sanctimonious moaning in the lower register.

Rule No. 6. No hand clapping in this studio.

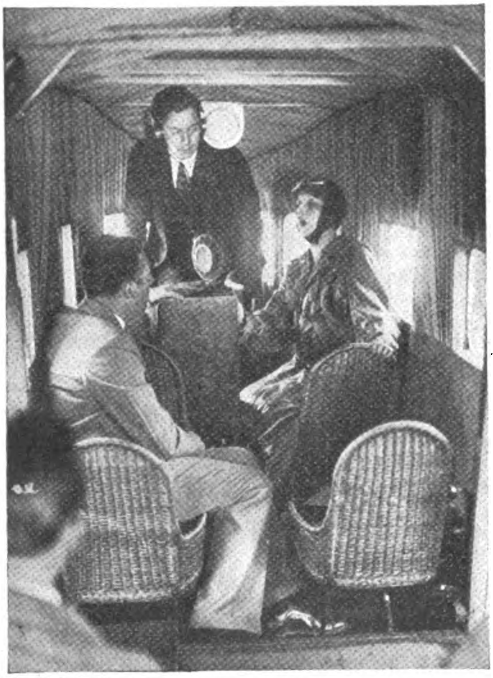
Rule No. 7. All boys under twenty years of age who play Hohner harmonicas are referred to the program manager of WEAF and WJZ.

Rule No. 8. No artist (especially female) will be permitted to tell the audience that he or she was "thrilled" or that it was a "perfectly wonderful experience."

Rule No. 9. If Major Bowes broadcasts from this studio, will he please refrain from calling his troupe his "happy little family." That is obvious applesauce.

Rule No. 10. Song pluggers will please apply to Mr. N. T. Granlund, seventh floor (third office to the right), Loew's State Theater Building, Broadway and Forty-fifth street, New York City, U. S. A.

Of course, we could go on writing these rules until the cows came home. What we really wanted to do was to show you that we are a big, bright-eyed boy, conscious of and alert to all of the sad little mistakes that our large-minded impresarios are making. The chances are that we might be wrong, too, but if we are as wrong as our impresarios, we will, on Thursday morning, March 25, rain or shine, take a nose dive from the top of the Columbus statue at the Fifty-ninth street entrance to Central Park.



Kadel & Herbert

A FLYING BROADCAST STUDIO

The cabin of the giant Sikorsky airship was converted into a studio when Maxine Brown broadcast her part of the program from a spot a thousand feet or so above the earth. The program was sent out on a 40-meter wave, was picked up at WGBS and rebroadcast on the station's regular wavelength.

* * *

Dramatic Reading and Other Whatsis

Mrs. Gloria Watkins Jones, patron of the arts, and wife of the wealthy local cigar manufacturer was one of the first to discover radio as a means of lifting the literary tastes of the masses above the level of the confession magazines and the illustrated tabloids. Mrs. Jones is a big, indignant person when it comes to the subject of appreciating the greater things in literature and she recounts, with not a little feeling, the slovenly tendencies of the modern reader who could easily be lead to believe that Oscar Wilde was a great ball pitcher of the 90's, that Newton invented the Fig-Newton or that Captain Dingle is the world's greatest writer of sea stories.

Now Mrs. Jones can practice her sophistication at her bridge parties with no objection on the part of this department but when some supposedly intelligent studio manager knowingly presents her with twenty minutes and one thousand watts of power something should be done about it. Permit any Mrs. Jones to heave in the throes of a recitation, wherein there is much tragedy and loads and loads of subtle literary perfection, and you commit one of the worst and most disgusting broadcasting crimes that can be committed in this or any other country. Here is one vote against dramatic reading on the air.

* * *

Negro Spirituals

A LOT of broadcast singers have lately gone in for the moaning of negro spirituals, and it's getting so that you cannot turn to the radio without hearing the white man's version of the colored man's prayer. There is nothing more easily overdone (that may not be strictly true, but let's assume that it is) than the sanctimonious wailing of darky hymns, and we must request that our studio managers consult this department before engaging any more quartettes all filled up with spirituals. By the time the second or third hymn is reached that gloomy, Alice-is-dead-in-the-next-room atmosphere is created, and you feel like going right out to the corner drug store where they wrap it up to look like laundry.

* * *

Some Extraordinary Announcements

EITHER Mr. Phillips Carlin (one of the WEAF boys) is a very subtle humorist and a thirty-third-degree announcer or we are just plainly and hopelessly dull. Perhaps you have had better luck with Mr. Carlin, but it has been our experience to completely fumble the meaning of nine of every ten announcements that this gentleman makes. It is more than barely possible that his reflections are a bit too esoteric for us but we are inclined to doubt this, for it was only the other day that our Research Department handed us a report on Carlin which seemed to indicate that his general registration record was low.

We copied a few of his announcements recently just for the purpose of examining them at our leisure, but so far all efforts at translation have failed. Our Psychology Department offers a prize of two full United Cigar Store coupons to any reader discovering a meaning, however vague, in the following Carlin announcements:

EXHIBIT NO. 1

"You are sitting all alone. The cat is asleep in front of the fireplace and it is six o'clock in the morning. You hear a gay whistle and you run out to see who it is and it happens to be the ice man. 'Lonesome.'"

EXHIBIT NO. 2

"Some say it was the joke you heard in your cradle, others the rattle. 'Pal of My Cradle Days.'"

EXHIBIT NO. 3

"A pile of logs and stone. The boys find this a very hard number. A pile of logs and stone indicate a home."

One could not truthfully say that Mr. Carlin is verbose, for it is evident that he has some definite thought in mind. He does not seem to be able to concoct a combination of words to convey that thought. It may be—and we just happened to think of this—that his thought is so weak that all of the words in the dictionary would not help it.

* * *

The Roxy Formula

ALL of our studio managers must have taken to their various cellars for the purpose of muttering to themselves on the day after Roxy's return to the air. A special messenger, dust-covered and breathless, has just placed a communication from 195 Broadway on our desk which states that all WEAF mail records were broken on Saturday, October 31, 1925, the day after Roxy's broadcast. We also have it on mighty good authority that all Eastern stations were broadcasting only to the immediate families of their performers on the night Roxy made his return to WEAF.

It has always puzzled us how Roxy's formula has so successfully kept all of our great studio managers baffled. Roxy is perhaps the easiest man in the world to follow because his methods are so simple. Of course, simplicity is a hard thing to fathom after all, and it would not be fair to be too harsh with the studio boys for their having permitted Roxy's very simple tricks to elude them.

If you've got any ear for music at all (we are quite sure that *you* have an ear for music, but we sometimes have our doubts about all the rest of the listeners in America) you know that Roxy does not go to the booking offices of the Sterling Vaudeville Circuit to find his musical talent. Trick No. 1 is to get good performers. Trick No. 2 (and this *is simple*) is that of maintaining variety by permitting his artists to sing or play but one or two numbers at a time.

Now that Roxy is exposed, we shall expect all of our great studio managers to follow him. Not that we would for a single moment underrate these hard-thinking fellows, but anyone wishing to place a little five to one bet on the outcome will please communicate with our third secretary, 627 West 43d street, New York, N. Y.

¶ *On page 98 of this issue a new department is inaugurated under the direction of Mr. Lloyd Jacquet.*

IN THE EXPERIMENTER'S LABORATORY

CONDUCTED BY LAURENCE M. COCKADAY

Some Methods for Determining the Distributed Capacity of Coils

BEFORE going into the methods of determining the distributed capacity of coils it may be well to briefly outline the advantages to be derived from decreasing this capacity.

This capacity arises from the existence of a series of nearly parallel wires in a coil. Any two adjacent wires are roughly analogous to two small plates of a condenser. No coil is, therefore, a pure inductance, but it may be considered a pure inductance with the summation of all the inter-turn capacities as a shunt capacity. Most of this capacity is between two adjacent turns because the capacity from one turn to the second from it decreases at a rate proportional to the distance between them raised to a power greater than unity. That is, the capacity does not decrease directly as the distance between the conductors is increased, as is the case in a condenser of the usual type where the stray field is negligible, but at a greater rate.

The main objection to this capacity lies in the fact that this series of small condensers is usually of a high-loss type. This is due to the fact that the wire insulation and some of the supporting material are in the electrostatic field and cause dielectric and resistance losses. Both of these decrease with increase in frequency, but when it is remembered that the power dissipation in a condenser increases directly with increase in frequency, the other factors remaining constant, it is evident they are still important. Other factors remaining constant (i.e., frequency, capacity and power factor) the power loss is proportional to the square of the voltage, so this should be kept low. This can be best accomplished by using a straight solenoid type of winding. In a coil of this type it is evident that if there is a potential difference of X across the coil, the potential difference (voltage) between two successive turns is $\frac{X}{N}$ where N is the number of turns.

The distributed capacity can be decreased by slightly spacing the turns. The losses can be minimized by improving the dielectric in the field, minimizing the amount of it and decreasing conduction (decrease resistance) between turns. Spacing the turns decreases the latter considerably.

Variable condensers have been improved to the point where they have only one percent, or less, the resistance of the average coil. Working on coils is, therefore, well worth while.

To measure the distributed capacity of coils a variable standard of capacity and a wavemeter are necessary. For rough work a variable condenser of the General Radio type No. 247 can be used. This should have a calibration curve.*

For the man who dislikes mathematics the graphical method of determining distributed capacity is best although this is less accurate than the other systems to be given.

$$\lambda = 1.885 \sqrt{L\,(C + C_o)} \qquad (1)$$

Where λ is wavelength in meters

L the pure inductance of the circuit in microhenries

C the value of the shunt capacity used in micro-microfarads and

C_o the distributed capacity of the coil in micro-microfarads.

Squaring both sides

$$\lambda^2 = 3.553\,L\,(C + C_o) \qquad (2)$$

As L is constant the relation between λ^2 and C is linear and the plot will be a straight line as shown in Figure 1. The slope of this line ($\frac{Y}{X}$ in Figure 1) is equal to 3.553 times L where L is the inductance of the coil. The distance from the origin (the point marked O) to the point where the linear curve crosses the abscissa (Z in this case) determines the distributed capacity. This follows from the fact that when λ^2 is made equal to O in equation (2) $C = -C_o$.

The value of the inductance can be determined from this curve by dividing the slope of the curve by 3.553 or

$$L = \frac{Y}{3.553\,X} \qquad (3)$$

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*See article by the author on page 386 of the October, 1925, issue of POPULAR RADIO.

For X, or the value of capacity to be used choose some convenient value. In Figure 1 X is 100 or the difference between 280 and 180 mmfds. (micro-microfarads). The corresponding value of Y, which is the increase of λ^2 between these capacity values, is in this case 102,500 or substituting in (3)

$$L = \frac{103,000}{3.56 \times 100} = \frac{1030}{3.56} = 289 \text{ micro-henries} \quad (4)$$

The value of L is in micro-henries since this was the unit used in equation (1). In this case it should be noted that only three significant figures were used. Actually with a small chart of this size only the first two figures should be used in the computations since because of the size of the chart and the accuracy in measurement only the first two will be reliable.

If in equation (1) C is very large as compared with C_0 the latter can be neglected for approximate determinations of L or λ. If, for example, C is about 1,000 mmfd. (.001 mfd.) and the measurement of L is made for an average coil designed for broadcasting frequencies the error introduced by neglecting C_0 is only of the order of 2 percent, assuming the determination of λ is accurate. If this is then used to determine C_0, which is what we are primarily interested in, the value gotten will be accurate within a fraction of a mmfd. which is ample. If then another determination of λ is made (i.e., the resonant wavelength of the parallel resonant circuit composed of the capacity C and the coil to be measured) at a low setting of C, C_0 then becomes a large percentage of the total shunt capacity to L. Knowing the approximate value of L and the value of C these can be substituted in (2) and the value of C_0 determined.

The following procedure should be used to get C_0. Connect the coil, the distributed capacity of which is wanted, across the variable standard of capacity. Set this condenser at a high setting, giving a high value of capacity C. This should be about 1,000 mmfd. The wavelength of this circuit should then be determined with a wavemeter.* A "set up" of this type is shown in Figure 2. The oscillator is shown at O, and C is the variable standard capacity. The coil is shown at L for which C_0 is wanted (it is placed on a small box shown in the foreground to shorten the leads to C) and W is the standard wavemeter. In this case the wavemeter had no resonance indicator in the circuit. The condenser C was set to a

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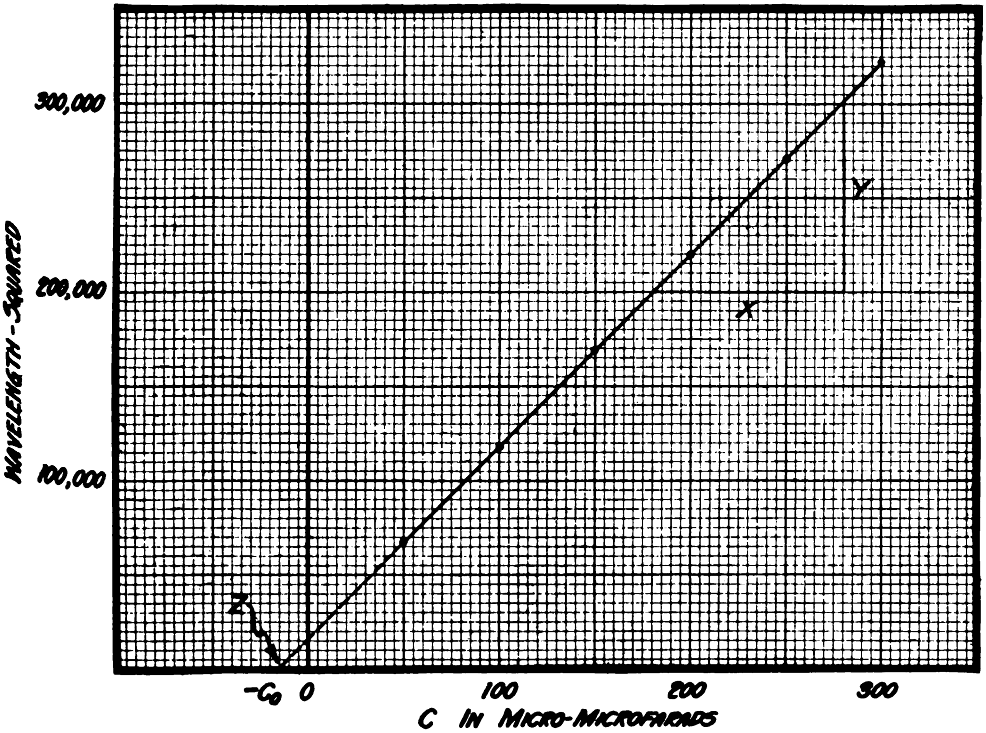
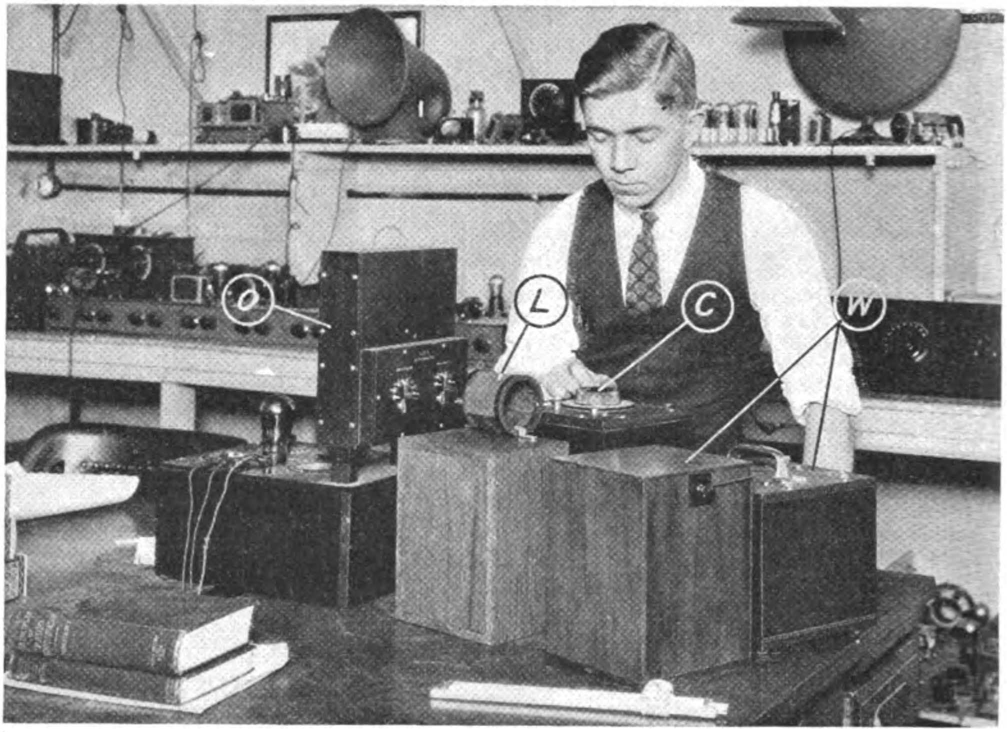
*See "An Oscillating Wavemeter," by S. Gordon Taylor, page 267, September, 1925, issue of POPULAR RADIO.



THE GRAPHICAL METHOD OF DETERMINING DISTRIBUTED CAPACITY

FIGURE 1: *Several wavelength measurements of a coil and condenser circuit are made and the wavelength-squared plotted against the capacity at each point. It is shown that the distance OZ represents the distributed capacity of the coil used.*



From a photograph made for **Popular Radio**

THE LABORATORY MEASUREMENT OF DISTRIBUTED CAPACITY

FIGURE 2: *The coil of which distributed capacity is to be measured is lettered L and its tuning condenser is called C. The oscillator O supplies the radio-frequency current to the tuned circuit LC and a wavemeter W shows the wavelength of the radio-frequency current. Results of these measurements are plotted as the curve of Figure 1.*

high value. Then O was tuned until there was a sharp deflection in the plate current meter. The coupling between O and the circuit LC was decreased until the deflection was very sharp indicating the latter was in resonance with O. The standard wavemeter was then tuned until there was again a sharp deflection in the plate meter of O. The wavelength reading of W then gave the wavelength to which LC was tuned. Then C_o was neglected and the readings of C, and λ, were substituted in (5) giving L within 1 or 2 percent depending on the relative values of C and C_o as gotten by subsequent calculations. The subscript 1 is used to indicate values of C and λ for the first or high wavelength setting and the subscript 2 for the second values of C and λ taken at a low wavelength.

$$L = \frac{\lambda_1^2}{3.553 \quad C_1} \qquad (5)$$

where L is in micro-henries and C in micro-microfarads.

Condenser C is then set at a low value (50 mmfd. or less if C is accurately calibrated) which is called C_2. The wavelength reading of this setting is called λ_2. These values are substituted in (6) which gives the distributed capacity C_o in micro-microfarads.

$$C_o = \frac{\lambda_2^2 - 3.553\,L\ C_2}{3.553\,L} \qquad (6)$$

If λ can be measured accurately and a more precise value of C_o is wanted L should be gotten by substituting C_1, gotten by direct reading, and C_o, from (6) in equation (2) and solving for L. This more precise value of L can then be substituted in (6). In the computations given more significant figures have been used than the theory of precision would warrant, but this has been done to provide an equation which is more valuable for accurate determinations. An equation can easily be worked out which will give C_o directly in one operation but this involves involution, or the extraction of roots, and is therefore somewhat more involved.

If the experimenter is interested only in the value of C_o the so-called "harmonic" method of determining it can be used. In this system intregal multiples of some given frequency are used. These can most easily be obtained by using some harmonic, say the second, of the oscillator. The value of the resonant frequency will vary inversely as the square root of the capacity since the inductance is constant. Hence the value of C plus C_o (the total capacity in shunt to the theoretically pure inductance L) will be one-quarter of that used for the fundamental when the second harmonic (or double the frequency) is used. Or mathematically

$$(C_f + C_o) = 4\,(C_{2f} + C_o) \qquad (7)$$

where C_f is the value of the variable standard at the fundamental, C_{2f} is the setting of the standard for resonance at the second harmonic frequency and C_o is the distributed capacity as before. Solving for C_o we get

$$C_o = \frac{C_f - 4\,C_{2f}}{3} \qquad (8)$$

where C_o is given in the same units that are used for C_f and C_{2f}.

Since the resonance point for the second harmonic is somewhat difficult to determine, particularly with a low-power oscillator, the oscillator frequency can be doubled by adjustment and the values of C_f and C_{2f} determined. This increases the possibility of error but makes computations simpler and is accurate enough for all ordinary work.

To facilitate this and numerous other measurements the experimenter's wavemeter should have both a wavelength and frequency calibration chart. The latter can be made by taking enough values of λ from the present curve and obtaining their frequency equivalents to plot a new curve. The relation is expressed in (9) where f is expressed in K.C. (kilocycles)

$$f_{K.C.} = \frac{300{,}000}{\lambda} \qquad (9)$$

—Hugh S. Knowles

How to Simplify Connections

A Handy and useful accessory has recently been placed on the market by a number of manufacturers; it consists of a battery cable which usually comprises five leads of different colors bound into a single cable. The colored leads make it easy to tell which should be used for the "A" battery positive and negative wires and the "B" battery positive and negative wires.

The use of such cable will go a long way to eliminate mistakes in connecting up as well as making a much neater job in hooking up to the battery.

The antenna wire should never be connected in the same cable as the battery wires, however, as this would make too high a capacity between the antenna and ground parts of the circuit with a corresponding loss in signal strength

A Milliammeter as an Aid in Preserving Batteries

If the experimenter will connect a milliammeter in series with his "B" batteries he will be able to tell just what plate current his set is drawing and by the use of "C" batteries he can reduce the total current necessary to operate the receiver to a low value that will permit of great saving in the life of the "B" battery.

Every experimenter should own a milliammeter for direct current with a scale reading of zero to 25 milliamperes that will take care of nearly all types of receiver.

Making the Tuned-radio-frequency Receiver More Selective

In some locations close to broadcasting stations, the ordinary tuned-radio-frequency set that employs two stages of radio-frequency amplification, vacuum-tube detector and two stages of audio-frequency amplification sometimes will not give tuning sharp enough, with the ordinary 100 to 150 foot outdoor antenna, to enable the user to choose between the local stations or to receive distance while the local stations are on the air. To eliminate this trouble it is suggested that the antenna be cut down to about 50 feet in length. This will enable much sharper tuning and although it may cut down the volume of signals from the distant stations somewhat, it will enable them to be received without interference from the locals.

The Old Reliable Single-layer Solenoid Coil

Recent investigations have proven the single-layer coils to be the best type that has yet been developed. The considerations of length over diameter should be very carefully gone into.

To get the maximum inductances in a single-layer coil the limits should be kept somewhere about an equal value for the length and diameter.

Coils in other shapes than cylindrical all will need a longer length of wire for a given inductance and therefore the ratio of inductance to resistance will be smaller with a corresponding reduction in the overall efficiency of the coils.

The distributed capacity can be considerably lowered by spacing the turns slightly on the tube upon which the coil is to be wound.

Sizes of wire should lie between No. 18 and No. 30 inclusive, to hold the resistance at radio-frequencies used in broadcasting and other short-wave work, down to a low value. There is not much difference between any of these sizes.

The coils may be wound with either double silk covered copper wire or with copper wire with one layer of cotton and one layer of silk.

Pure DC Power Supply for a Five-watt Transmitter

Too many amateur transmitting stations in operation today have an alternating current note that produces considerable interference. It is true that many of these have rectifiers and filters in the power supply circuit, but still the signals transmitted carry the unmistakable hum of an AC modulation. Probably not more than ten or fifteen percent of the amateur stations have a really pure, steady DC output, in spite of the fact that the great majority of owners have gone to the trouble and expense of equipping their stations with rectifiers and filters. In many of these cases the rectifier is not functioning properly, although, of course, there are numerous cases where the filter does not have sufficient inductance, or capacity.

Many amateurs blame their trouble on the use of short waves, claiming that it is impossible to obtain a good DC note on short wavelengths. Others are laboring under the impression that a pure DC note is so sharp in tuning that slight swinging or unsteadiness makes it unreadable.

The tone quality of the note is not in itself important, but when the air is full of static there is no question but that the high "birdie" note of DC gets out at distances that cannot be approached by AC or poor DC notes.

In tests made at one of POPULAR RADIO'S experimental stations it has been proved conclusively that a pure DC note is easily obtainable; that it can be made steady so that its sharp tuning qualities are not a drawback, and that it is more easily read through static or other interference. Following is the equipment used for supplying the pure DC to the transmitter, using the 110-volt AC house lighting line as the source of power.

The power-supply equipment to be described is for use with a transmitter using a single 5 or 7½-watt tube. When larger tubes are used the only change required is to provide suitable equipment to supply the higher voltage required and to increase the number of rectifier jars. The reader may easily make these adaptations himself.

Parts for Power Supply Unit for Five-watt Transmitter

1 Dongan type O1, 200-watt power transformer, voltage output 550 each side of center tap:
1 Dongan type D7, 80-watt filament supply transformer, voltage output 8, with center tap;
1 Acme 30 henry choke, 0.15 ampere current carrying capacity:
2 National Condenser Co.'s paper condensers, 2 mfd. capacity, tested for 1,000 volts;
1 Chemical rectifier (See below for constructional data);
1 Double pole, single throw snap switch, 110-volt;
1 Allen-Bradley Radiostat (For use with VT-2, UV-202 or C-302 tubes; not needed with the new UX-210 tube).

The Rectifier

In making up a rectifier for use with an amateur transmitting set the usual practice is to use a miscellaneous collection of jelly glasses for the jars, and strip lead and aluminum for the metallic elements. There is no question but that such a combination will work—probably as well as any other materials—but at best such a rectifier is an unsightly mess. A rectifier which is much more pleasing in appearance and which does not become crusted all over with crystallized solution can be made as easily, and with little more expense. It is such a rectifier that is to be described here.

The parts needed are:

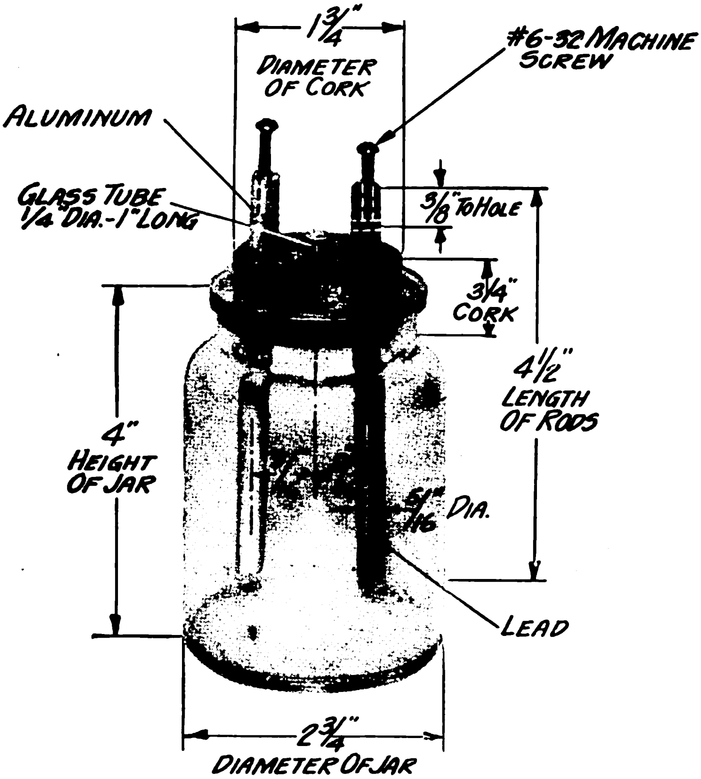
24 half pint "salt mouth" bottles, and cork stoppers to fit. See Figure 3 for dimensions;
9 feet of aluminum rod, 5/16 inch in diameter;
9 feet of lead rod, 5/16 inch in diameter;
2 feet of glass tubing, ¼ inch in diameter;
48 round head brass 6-32 machine screws, ½ inch long;
1 package "20 Mule Team" borax;
1 can lye;
6 quarts distilled water.

Before starting with a description of the constructional details, a word of warning should be given regarding the metals used. It is essential that both the lead and the aluminum be chemically pure. It is wise to purchase the metal rods from a chemical supply house, because they usually carry only the purest of metals. It is also necessary to exercise the utmost care in cleaning the metals and in absolute cleanliness. Use distilled water, which can be purchased from the druggist, or from a storage battery service station.

The first operation in the construction of the rectifier is to cut the lead and aluminum rods into 4½-inch lengths, making twenty-four lengths of each. Two holes should be drilled in each of these lengths, one down from the top which should be threaded to accommodate the 6-32 screws, and the other at right angles to the first but not threaded as it is used only to slip the connecting wires through. See Figure 3 for the necessary dimensions and the position of the holes.

Set the metal elements aside for the time being. Then prepare the cork stoppers as shown in Figure 3. Three holes are drilled in each, the outer holes for the metal rods and the center hole for a one-inch piece of the glass tubing. This latter serves as a vent pipe and also permits the addition of distilled water from time to time to make up for evaporation. To cut the glass tubing into 1-inch lengths a three-cornered file is used. File a small niche in the glass at every inch and then break the tubing at these points with the fingers. It will be found that the break will be clean cut and square.

The solution may now be prepared, or, it may be advisable to prepare the solution before the work described above is done, because the solution *must settle for about twenty-four hours before it can be poured into the rectifier*



THE FINISHED RECTIFIER JAR

FIGURE 3: *All the necessary dimensions are given here for the assembly of a rectifier jar. Complete constructional data are given in the accompanying text.*

jars. The vessel used for mixing the solution may be an earthenware crock or an enamel pot. In making the solution for the model rectifier constructed in the laboratory two glass bottles, each of a gallon capacity, were used. These are convenient because the bottles can be picked up bodily and shaken, thus mixing the solution thoroughly, and can be corked up while the solution is settling, thus keeping the dust out.

The solution used is made up of six quarts of distilled water and the entire package of borax. If the water is heated in a clean vessel before adding the borax it will be found that the borax will dissolve more rapidly. However, it is not necessary to heat the water. Mix the solution thoroughly until all of the borax has dissolved (if the water is hot) or until no more will dissolve. Then set the solution aside for twenty-four hours, during which time the excess borax will settle to the bottom, or crystallize on the bottom and sides of the vessel. It is only the clear liquid that is used in the rectifier, so in dipping or pouring the solution from the vessel try not to disturb the settlings. Do not become impatient and use the solution in less than twenty-four hours, because this will result in a creeping crystal formation in the rectifier jars which is decidedly messy and unattractive in appearance.

Now comes the cleaning process. The jars and corks should be washed in warm water with soap, then thoroughly rinsed in clean cold water. Then they may be set aside.

The cleaning of the metal elements is perhaps the most important job of all. In an earthenware, china, glass or enamel vessel, mix one-quarter of a can of lye in about two quarts of boiling water. Do not use a metal pot for this purpose and do not use enamelware if the enamel is chipped. Also be very careful not to get any of the lye solution on the clothes or hands, as it will eat almost anything it comes in contact with. Treat it with as much respect as you would a powerful acid. Do not use it indoors if this can be avoided, as there are some fumes from the mixture which are unpleasant to breathe and will tarnish silver and other metals which may be in the

Clean the metal elements one at a time, finishing all the aluminum pieces before starting with the lead. Hook a wire through the hole in one end of an aluminum element and lay it in the lye solution until it froths violently. Then remove it and rinse in cold running water. Rinse it thoroughly, and lay it out on a clean piece of cloth or paper. It is important not to let the cleaned aluminum come in contact with the hands or anything which will permit it to collect grease or dirt. When the aluminum has been cleaned with lye it should be a light silver color, almost white. If it is not, it is an indication that the aluminum is not pure and is unfit for use in a rectifier.

Next clean the lead elements in the same way, using the same solution. The lead will not froth as did the aluminum. There will be no visible indication of the cleaning process on the lead. Simply let each piece rest in the solution for about twenty seconds; then remove, wash and lay out on paper as with the aluminum. Do not let the lead come in contact with the aluminum, however.

Everything is now ready for assembly of the jars. To insert the elements in the corks, wrap a piece of clean paper around the lower end of the element to protect it from the fingers and force the top end through one of the holes in the cork. An aluminum element goes in one outside hole and a lead element in the other. The glass tube is placed in the middle hole, as explained above. When the two elements and glass tube have been placed in the cork the whole cork is inserted in the neck of one of the bottles, which has been filled almost to the neck with the borax solution. The jar is then completed and should look as shown in Figure 3. The lower ends of the metal elements should be at least ½-inch from the bottom of the bottles.

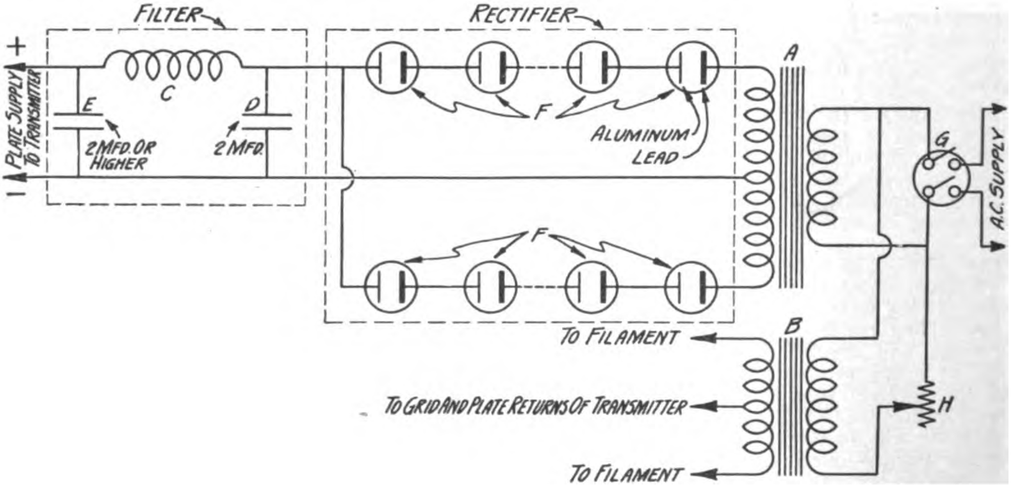
When the twenty-four rectifier jars have been completed thus far, they must be formed. This is most conveniently accomplished by simply connecting them up in the circuit in which they are to be used, as shown in Figure 4.

When the alternating current input to the transformer is turned on with the rectifier connected across the transformer secondary, there will be a momentary rush of current through the rectifier circuit. This current will be reduced to practically zero within a few seconds, however; an indication that the rectifier is starting to form.

It is well to leave the rectifier connected in this way for a few hours, as an aid to the forming process. Then it may be connected up to the transmitter. The forming process will continue in the ordinary operation of the transmitter thereafter.

It may be found that one or perhaps more of the rectifier jars does not function as it should. One test for this is to measure the voltage drop across each jar with an ordinary DC voltmeter. Measure one cell at a time. If any of them show no voltage they are defective and should be removed from the circuit. It will be found that the voltage across some jars may be only half that across others, but these may be left in the circuit. Any that are lower than half the voltage of the highest should be removed. These may either be made over with new solution and new aluminum electrodes, or they may be left out entirely, as eighteen or twenty jars are sufficient where the transformer voltage rating is between 500 and 600 on each side of the center tap.

The above description covers a rectifier suitable for an input of 600 volts to each half of the rectifier. For use with a transformer having an output of 1,000 to 1,200 volts each side of the center tap a minimum of thirty-six rectifier jars should be used, eighteen in each half. In any case it is well to make up a few extra jars so that defective ones may be weeded out



THE DIAGRAM OF THE POWER SUPPLY UNITS

Figure 4: *The transformers, rectifier and filter are required to furnish a pure DC input to the transmitter, where the alternating current house lighting lines are used as the source of power. In "forming" the rectifier jars this circuit may be used without connecting the filter output terminals to the transmitter, or "forming" may be accomplished with the output connected to the transmitter. In the rectifier portion of the diagram only eight jars are shown. This, of course, is not the number actually used.*

and still leave enough good ones. This is suggested because when new jars are added to old ones difficulty is frequently encountered in getting the new ones to form properly.

The Filter

After the alternating current of the transformer output has been rectified it is unidirectional, but nevertheless will not result in a DC transmitted note. This is due to the fact that the DC is pulsating at a 60-cycle frequency. By means of a suitable choke coil in combination with large fixed condensers the pulsations can be smoothed out to such an extent as to produce a pure DC note. Figure 4 shows the connections for a suitable filter, as the condenser-choke combination is called.

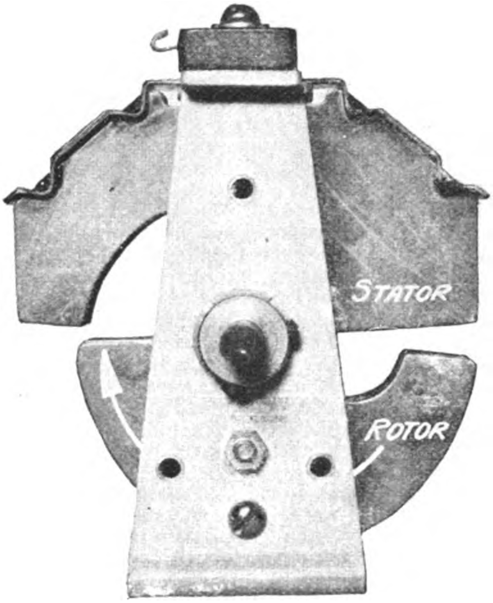
The condensers used may each be of two microfarads capacity, capable of withstanding the voltage used. With the above rectifier and a 600-volt output transformer, for instance, the condensers used are rated at 1,000-volt breakdown. The choke coil used is one with an inductance of 30 henries. Smaller chokes may be used, but the larger choke has proven more effective in reducing the hum. To obtain a pure DC note with a choke of small inductance it is necessary to make use of a larger capacity condenser than used with a large choke so the cost of parts is approximately the same either way.

The Filament Supply

It is a common and advisable practice to operate the filament of the transmitting tubes from the AC house line, with the voltage stepped down by means of a suitable transformer. It is evident, however, that the grid and plate returns to filament will not be constantly either positive or negative in such a case because the ends of the filament change polarity 120 times per second, in the case of 60-cycle current. Naturally this results in fluctuations of grid potential, with corresponding fluctuations in the plate current. This condition is partially gotten around by using a filament step-down transformer which has a center tap in the secondary winding. The outside connections of the secondary winding then supply the filament, while the grid and plate returns are connected to the center tap, thus maintaining them at constant zero potential.

In addition to the use of the center-tapped transformer, it is important that bypass condensers be connected across from the center tap to each end of the filament to bypass the radio-frequency currents around the transformer winding. Even with an efficient rectifier and filter, the failure to use a center-tapped transformer and bypass condensers in the filament circuit may result in an AC note largely nullifying the work accomplished by the rectifier and filter.

Some means must also be provided for controlling the filament voltage. Entirely too often this is accomplished by inserting a rheostat in series with one side of the filament. This practice accomplishes its object, but in doing so has the effect of throwing the filament center tap off center. The filament voltage should be controlled by means of a rheostat inserted in series with the primary of the filament transformer. The ordinary rheostat will, of course, not be suitable for this purpose. Special primary circuit rheostats are on the market, however, made by the Allen-Bradley company. There is their E-210 model for use only with 5-watt tubes, and their "Radiostat" for use with both 5-watt and higher power tubes. With an 8-volt 80-watt filament transformer a rheostat is not needed if the UX-210 power tube is used.



THE SYNCRODENSER

FIGURE 1: *The arrow shows the direction of rotation of the rotor to give a straight-line-frequency curve. It must be moved in this direction to balance the two condensers for single control.*

The use of a single transformer for supplying both plate and filament is not recommended. Such a transformer has a single primary and two secondaries, one for the high voltage plate supply and the other for the low filament voltage. It is therefore obvious that any resistance connected in the primary circuit to cut down filament voltage will also cut down the plate voltage correspondingly.

Balancing the Single-control Superheterodyne

A NUMBER of inquiries have been received as to the best method of balancing the two variable condensers which are operated in this receiver (described in the October, 1925, issue of POPULAR RADIO) by a single dial.

To proceed with the balancing operation, first loosen the set screws in the collar that connects the two condenser shafts so that the rotors may be moved independently.

Then attach a small dial to the shaft of the rear condenser.

Next set the small vernier condenser so that its rotor plates are about one-third meshed.

Now tune in a broadcasting station the same way as with any two-control superheterodyne. It will be noted that when the loop is tuned to the incoming signal it will be possible to hear the station at two different settings of the oscillator condenser (rear). The lower of these two points is the one that should be used.

When the station has been tuned in with maximum signal strength, tighten the set screws in the connecting collar and the receiver will be ready for operation with the single control.

It is advisable to balance the condensers on a low-wave station. A good check may then be obtained by tuning in another station at the other end of the scale. If this is found possible (it will probably be necessary to adjust the vernier condenser slightly) the receiver is properly balanced.

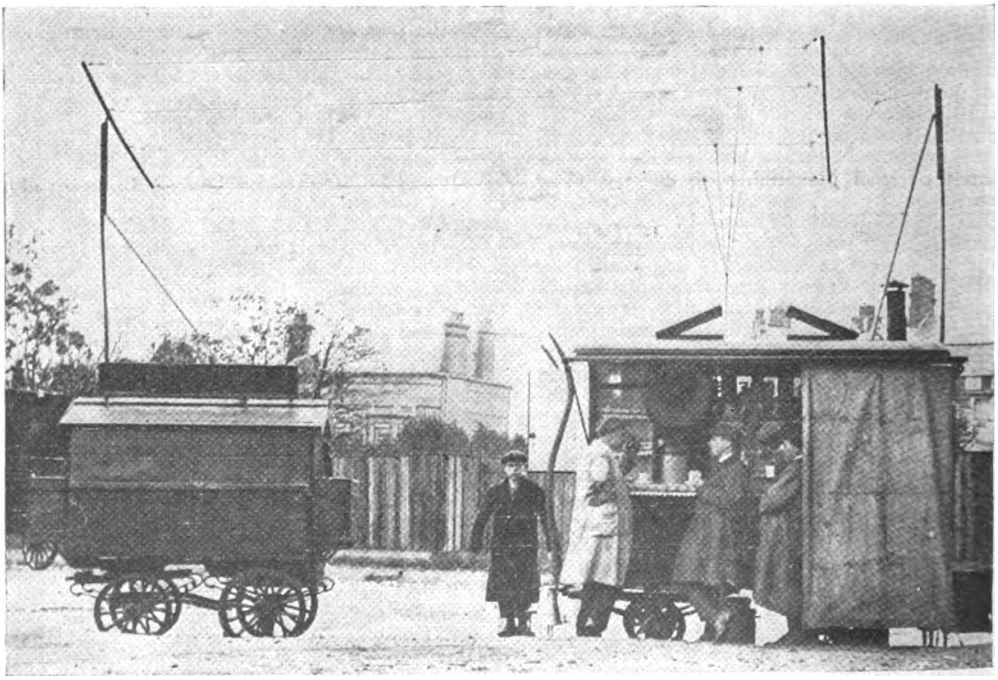
If, however, it is found that stations at the other end of the waveband cannot be tuned in properly, even with the use of the vernier condenser, try rebalancing the condensers with a medium wave station, say around 380 meters. The leeway allowed in the capacity of the vernier condenser should be sufficient then to permit tuning in high or low wave stations.

When it is necessary to use the vernier condenser to tune in a station with maximum volume the main tuning dial should be readjusted after each movement of the vernier condenser.

As in the case of all condensers, zero setting is obtained in those of the straight-line-frequency type when the plates are unmeshed. With the condensers specified for use in this superheterodyne receiver, however, capacity should be increased by turning the rotor in a clockwise direction, as shown in Figure 1. Never turn the rotor in an anti-clockwise direction from the zero point when using these particular condensers because then it will be found that the low-wave stations all fall within a very small band on the dial scale. If operated properly, that is, in a clockwise direction, it will be found that the low-wave stations spread out over a goodly portion of the dial scale. This is simply another way of saying that the straight-line-frequency effect is obtained only when capacity is increased by turning the rotors in a clockwise direction.

It is also essential in balancing the condensers that both be turned somewhat clockwise from the zero point. Unless the rotors are both meshed on the same side of the condensers, the capacity of one condenser will be increased while that of the other is decreased, after the two have been coupled together to be operated by the single dial. In that case, of course, the condensers will not be balanced on any wavelength except the one on which the balancing process was carried out.

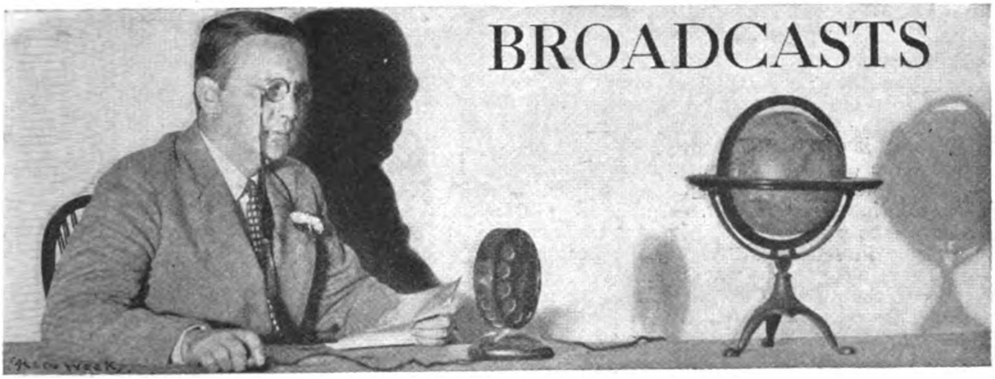
—S. GORDON TAYLOR



Kadel & Herbert

"WITH MUSIC BY THE HOTEL SAVOY ORCHESTRA"

By the simple but ingenious idea of installing a receiving set on his coffee stand, this humble restaurateur furnishes his guests with the same music as is enjoyed by the patrons of London's swagger hostelry.



BROADCASTS

CONDUCTED BY J. ANDREW WHITE

In this department the Dean of Broadcasters—whose voice is known to millions of broadcast listeners—records items of interest and value to all radio fans everywhere.

Will Wavebands Supplant Street Bands?

It appears that the thrill that comes once in a lifetime to the small boy is to become even more rare in occurrence, with the possibility in sight that the brass bands which have since time immemorial headed street parades are to disappear from the leading position of these processions. Such a fell blow at tradition landed in Chicago recently, it is reported, when KYW transmitted band music so successfully to the open air parade which opened the 1925 National Radio Exposition that the marchers completed their procession along Michigan Avenue to the home grounds without the aid of the customary marching musicians. The parade carried with it a number of radio receivers and powerful amplifiers which supplied the full volume of brass so clearly that another pioneering achievement in a new field for radio was voted a complete success.

* * *

A Princely Tribute to a Radioman

In the reports of the rousing welcome which was extended to the Prince of Wales when he arrived home after his 25,000 mile voyage to South Africa and South America, considerable space was devoted to the manner in which the heir to the British throne recognized personal services of the officers and others in the official party and the distribution of numerous gifts and souvenirs. Yet that which was probably the most considerate act of all received scarcely any notice. It was the speeding up of the battle cruiser *Repulse* so that she would arrive at Spithead earlier than originally intended, in order that a young radio operator on board the vessel would be enabled to attend the funeral of his father, who died at London several days before the returning voyagers were due home. The operator was the son of Fred Bramley, Secretary General of the Council of the Trade Union Congress.

* * *

"Rag Chewing"—by Radio

The ability to carry on a successful half-hour's conversation appears to be the sole requirement for membership in the novel organization known as the "Rag Chewer's Club," but when it is added that this must be accomplished by radio and the friendly confab over the ether waves directed to and maintained with one who is already a qualified member, then it is understood why those who have accomplished the feat compose an honorary group of the membership of the American Radio Relay League. The unique fraternity of amateur radio men has already enrolled several thousand enthusiasts in the few months of its existence, and the roster shows that there are friendly conversationalists of the requisite ability in every state in the Union, in every province in Canada, and that six countries in Europe and Asia are represented.

* * *

Heat, Light and Power *via* the Ether?

Coincident with the announcement of the amateur half-hour air talkers organizing themselves, comes word from London that science is scheduled so to improve things that the very foundation of this particular organization is threatened. That is, if we are to take seriously the prediction of Professor A. M. Low, who is quoted in the daily press as saying: "The demand for speed and yet more speed will shorten business conversations to a matter of seconds or fractions of seconds. A few rapid facial expressions and some thought waves will serve the purpose of the present day thirty-minute conversation."

Professor Low predicts a lot of other things, including the transmission of power by radio, because radio waves and light waves are the same; it is only a question of the length of the wave. It is confidently to be expected therefore that some day scientists will shorten the radio wave to the length of light waves, and then we will have radio light. And since heat is also a type of wavelength, he sees nothing improbable in science converting the heat at the Equator into radio waves and broadcasting them to the poles, where, of course, the process would be reversed with reconversion into heat waves. He concludes that this power "will be free like water."

All of which was current and snappy conversation when I entered the radio field more than fifteen years ago—that is, all except the part which predicts the furnishing of power free. That is new, so the item stands.

* * *

How Broadcasting Settles the Labor Problem in Venezuela

A story worthy of an O. Henry setting is contained somewhere within the dispatch from Venezuela, that the Government has temporarily banned radio receiving sets because they keep people there from working. It appears that Venezuela has a large number of listeners, considering its population, and many of them give up their afternoons to enjoyment of broadcasting instead of going back to work after lunch. An official ban was put on afternoon programs, therefore, several months ago, but operators on ships entering Venezuelan harbors and in private broadcasting stations in the oil belt, over whom the Government had no control, continued to send out daytime programs and to cope with the situation the Government was forced to the expedient of barring the importation of receiving sets. This has resulted in a marked increase of popularity of the owners of sets which reached the interior before the ban went into effect, and even the smallest Venezuelan villages, it is said, have community listening-in parties.

* * *

The Effect of Radio on Home Life

In a conference on modern parenthood held under the auspices of the Child Study Association of America at New York, radio was held to be an unmixed blessing to family life, though the automobile and the motion picture were thought to be disturbers of hearthside unity. This viewpoint was presented by Dr. John M. Cooper, associate professor of sociology at the Catholic University, Washington, D. C., whose subject was the effect of machine made recreation on family life. The topic followed a lengthy discussion of whether religion tended to unite or separate family groups into factions because of the serious problem presented to many conscientious parents, who, themselves subscribing to no given faith, yet felt that their children should receive religious training.

* * *

Bangkok Takes to the Air

Bangkok is now broadcasting. The first important program in Siam, it is reported, was arranged by the Signal Corps of the army, with the assistance of the cavalry band, the musical selections and some news items provided by the local newspaper being received at five installations located at Hua Hin, Ayudhuz, Korat and at two of the official palaces. Satisfactory reception continued throughout the three hours scheduled for the program.

* * *

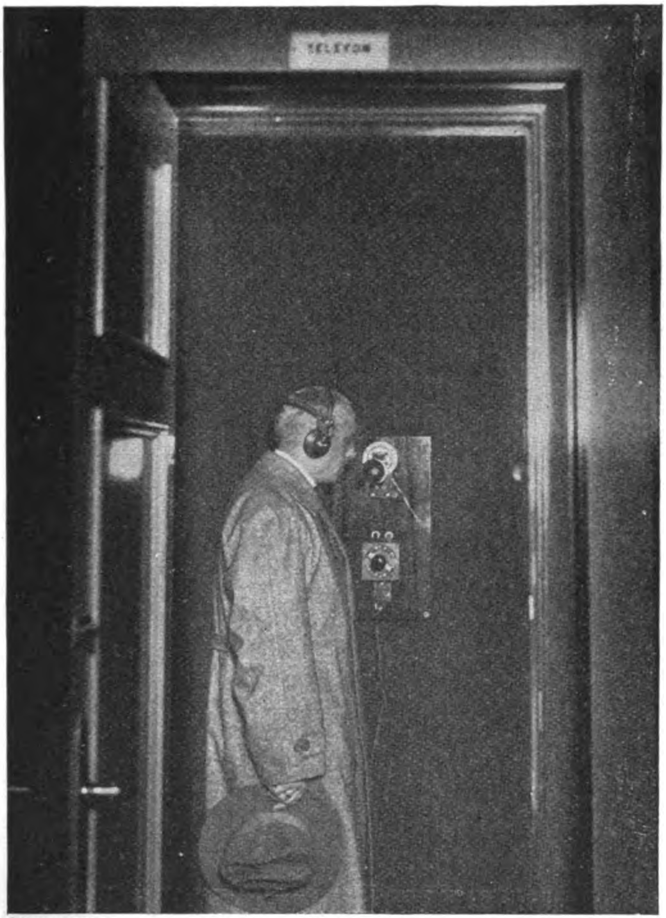
A "Minister of Communications"

Cuba may be establishing a precedent that the United States may follow in unifying its communication activities under one head. The Cuban Director of Telegraphs appears to be

Kadel & Herbert

FIFTY-FIVE WORDS A MINUTE WINS THE CONTEST FOR CODE RECEPTION

Fifty-five words a minute were received and recorded without an error by Joseph Chaplin in winning a contest in which speed and accuracy were the two essentials. The winner is the smiling operator seated third from the left.



Fotograms

THE FIRST RADIOPHONE BOOTH ON AN OCEAN LINER

Telephone booths from which the passengers can ring up and converse with shore stations or other ships within a few hundred miles radius, have been installed for the first time on the ocean liner Berlin. *The phone is connected directly with the ship's radio room where all the transmitting and receiving apparatus is located.*

the administrative head of radio activities, in the new order which has created a department to handle matters pertaining to radio, telegraphy, posts, railway, ship and air lines. The Government of Cuba, a member of the international convention, controls eight commercial stations and all radio except broadcasting, which being operated for entertainment and not for gain, is permitted to be carried on in private hands. Thirty-six broadcasting stations are in operation: among the larger is that owned by the telephone company, PWX. Another is operated by the tobacco monopoly. Only ten of the broadcasters operate with one kilowatt or more power incidentally, although Cuban call letters are familiar to American fans all over the country.

* * *

Cash Prizes for Radio Fans

A PRIZE of fifty dollars has been awarded to a Canadian amateur as the first recognition of a suggested improvement in the reception of pictures by radio. G. J. Shadick, of Regina, Saskatchewan, was the radio enthusiast to win the first award, his recommendation being to use a blank sheet of paper on the recording or receiving cylinder of the radio apparatus, around which he proposed to wrap a sheet of ordinary carbon paper, the movements of a metal stylus over this sheet of carbon paper reproducing the writing or drawing transmitted from the sending set. The plan is an obvious improvement on the pen and ink method now in use. Two additional awards are to be made public later by C. Francis Jenkins, the Washington inventor, who has announced that prizes aggregating $175.00 every two months will be presented to fans who offer practical suggestions which can be adopted for improving the Jenkins method of transmitting pictures by radio.

Fanatical Censors Now Seek to Ban "Indecent" Music

ALMOST any radio fan will agree that there is a lot of "crazy" music on the air these nights, but few would undertake to say that any of it is "indecent." The problem of determining that very difficult difference, however, came up recently in the capitol city of our fair land, when from a musty file of police regulations some one dug up an order forbidding "indecent music" and put it up to the Washington guardians of law and order to enforce the official "don't"—if they can agree on what it prohibits. The difficulty seems to rest with deciding whether swaying intonations are to be blamed for men forgetting home and babies, temporarily, or whether the important thing is that the tom-tommy sort of Oriental music should be confined to its point of origin, somewhere in the deserts, where, as one of the policewomen said, "the desert natives have self-respect enough to dance by themselves." At last reports the authorities were wide apart in defining a standard.

* * *

Will Radio "Standardize" Our Speech?

BROADCASTING is suggested as one means of standardizing speech by none other than Poet Laureate Bridges, in a tract of the Society for Pure English. That seems to be a good thought, so far as it goes, for radio may well be called a monitor of enunciation. But pronunciation—that is quite another thing. Standardization there looks impossible. We all have individualisms of pronunciation, and that seems to be a good thing. After all, whether we agree or disagree with the way the other fellow says it, what does it matter? Houston in Texas and the street of the same name in New York sound entirely different when spoken by natives of the two cities, and Greenwich and Haverhill and Los Angeles are others it is immediately apparent it would be hard to get together on. Personally, it is rather a pleasant shock to me to hear someone on the air who happens to live in another part of the country pronounce a name a little differently from the way I do. I figure that he is right, and so am I, for that matter; we both understand each other, anyhow, and, after all, that is all that matters.

* * *

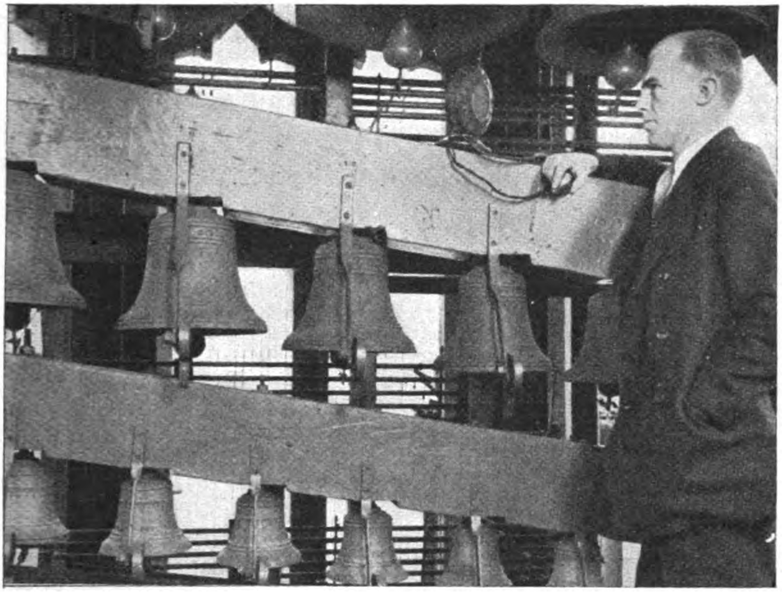
96 Hours of Continuous Listening In

ENTHUSIASTIC fans have made all manner of boastful claims as to the number of continuous listening hours they have put in at a radio receiver, but the most ardent dial manipulator will certainly have to sing low in the face of the claim of Mike Newman, veteran showman, who recently drove from Los Angeles in the interests of a movie film and announced on his arrival that there was no such thing as "silent hour" on the trip across country with a radio receiver mounted back of the driver's head going practically all the ninety-six hours and fifteen minutes running time required to travel 3,370 miles of the journey.

G. Crowther, England

A SHORT-WAVE TRANSMITTER THAT HAS COVERED OVER 5,400 MILES

Communication in daytime with a Rio-de-Janeiro amateur, M. Fresin, is the accomplishment of this English amateur, Herbert Hiley (G.21.H.) of Keighly, Yorkshire, England. The transmission was made with a Hartley loose-coupled circuit on a wavelength of 42 meters with 15 watts on the aerial.



Kadel & Herbert

CHIMES THAT PEAL ACROSS A CONTINENT

By the simple expedient of bringing the microphone into the belfry of the Park Avenue Baptist Church in New York, the music of the famous carillon presented by John D. Rockefeller is now broadcast as a regular feature from Station WJZ.

Only One State Without a Station

NEVADA is the only state in the Union which now has no broadcasting station. Wyoming was out, but the licensing of the new station, KFBU, at Laramie, brings the state of large plains back to the fold.

* * *

The World Buys American Radio Apparatus

TWENTY-NINE countries of the world are now importing American radio equipment, and the estimated total for the year has been set at $8,334,000, a new record. In the first eight months of 1925, the orders ran nearly three million dollars more than for the same period last year, with the indications pointing to Japan becoming our largest customer, with Canada and Great Britain respectively second and third.

* * *

An Amateur Radio Net to Cover the Country

AN amateur radio network covering practically the entire nation is being prepared by the Signal Corps with a view to securing the aid of some 3,000 amateurs for the establishment of additional communication channels which could be used in national emergencies and for the communication of the national guard and the reserve and civil units of the army. Those who would like to enroll in this new auxiliary service are invited to get in touch with the Corps Signal Officer of their own area, Corps headquarters being located in Boston, New York, Baltimore, Atlanta, Columbus, Chicago, Omaha, San Antonio and Presidio, Cal.

* * *

16 Percent of American Homes Have Radio

ONE of the latest estimates of the extent of radio is that there are approximately sixteen receiving sets to every one hundred American homes, compared with fifty-two automobiles and thirty-six talking machines. Figuring on that basis the conclusion is reached that seven years more will be required for the number of radio sets to pass the number of phonographs.

* * *

All Wavelength Limitations Are Off—in Esthonia

ALL wavelength limitations in broadcasting have been removed in Esthonia, a matter which will be of some interest to designers of radio receiving equipment who have been handicapped in building sets for foreign markets which, as in the case of Esthonia, have up to now so restricted the operable band of wavelengths that the ordinary type of broadcast receiver could not be used.

Hotel Has Radio Rental Service

A RADIO service for guests has been started at one of New York's leading hotels. A six-tube portable receiver is placed in one's room on a reasonable renting basis. The sets are kept in the electrician's office and may be rented by notifying him.

* * *

Radio As a Dramatic Plot

RADIO plays a leading rôle in a rollicking German comedy entitled "Rundfunk." This is the first German theatrical production in which radio furnishes the principal motif. The story is that of a merry widow and an irascible widower, and also of the widower's daughter and an opera star, who are brought together through the girl's hearing the artist sing over the radio. The manner in which the audience followed the radio jargon and slang demonstrated how universal radio already has become in Germany.

* * *

The World's Radio Headquarters Without a Station

IT seems strange that the radio headquarters for the world at large should have no local broadcasting station of its own, but that has been the case with Berne, Switzerland, up to recently, when a public subscription was started to raise 200,000 francs to provide for the station proposed by the Radio Club of Berne. This particular Swiss city, it may be explained for the benefit of newcomers into radio, has long been the headquarters of the International Telegraph Convention, where international regulations are made and call letters assigned to the various subscribing nations.

* * *

Radio on Gondolas

IT is reported from Venice that radio amateurs there have hit on a particularly bright idea to attract tourists to their particular crafts. Many of them, fortunate possessors of gondolas, have fitted them up with receiving sets, and go floating along the canals of a moonlit night. The effect is surprisingly romantic when turning a corner in a silently gliding gondola to hear from the next canal, wafted on the night air, some dreamy love melody from the Vienna or Italian Station.

* * *

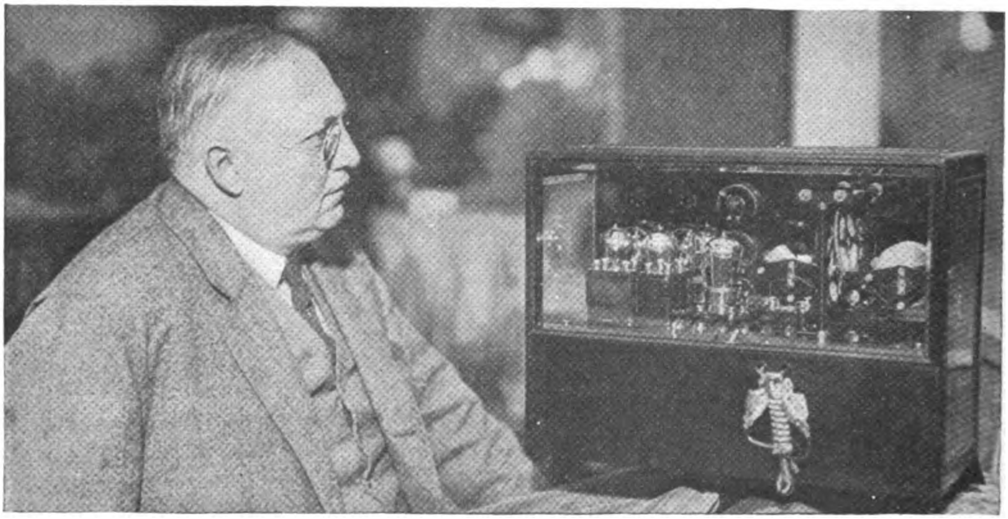
They Take to Radio Instead of Drink

THE British workman of today prefers radio to whisky, according to Captain Charles Nicholson of the Salvation Army. "Drunkenness has been reduced by one-half during the last few years," the Captain reports, "and many public drinking houses are often empty on Sunday evenings."

* * *

Yugoslavia's First Steps in Broadcasting

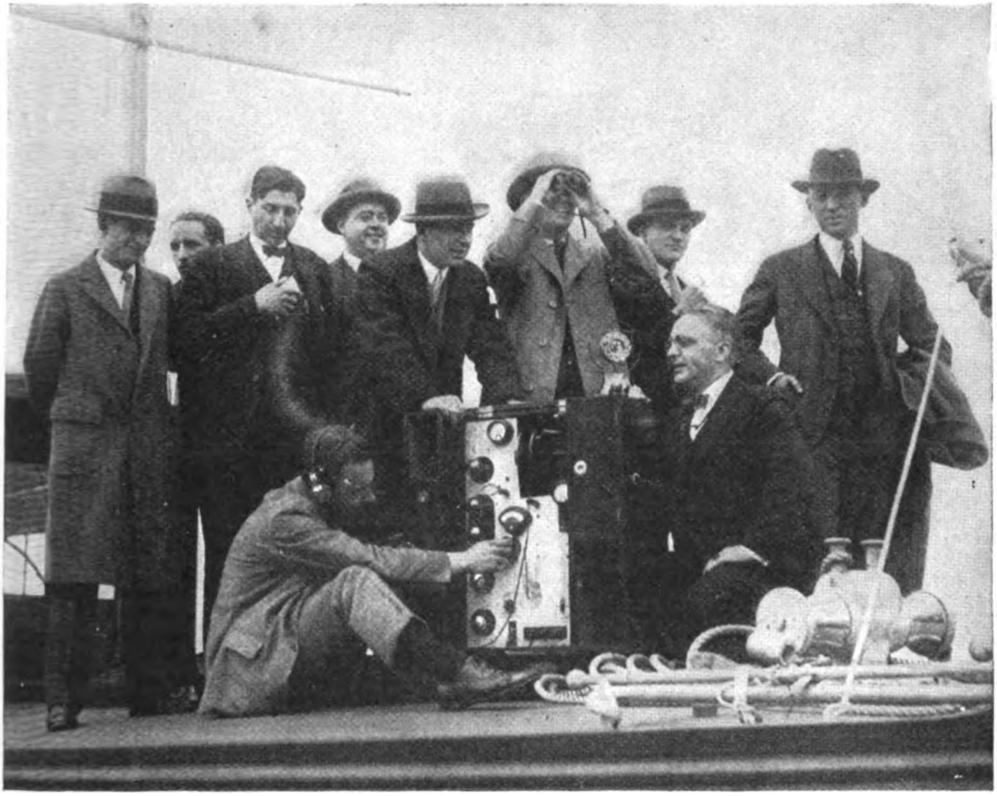
YUGOSLAVIA is to have a broadcasting station, secured from Germany on reparations account. It is to be erected near Zagreb, but as there are at present only 145 receivers in the homes nearby, the radio station will be used for a time at least solely for the State. It is hoped that later it will be released for general use.



Kadel & Herbert

A GLASS-INCLOSED RECEIVER

The noted doctor and X-ray specialist, Dr. F. L. Satterlee, demonstrates a set using his circuit that is claimed to work without an antenna. The theory of operation is based upon a tuned-ground system.



International

BROADCASTING "SIDE-LINE" REPORTS OF BOAT RACES

One of the features of this summer's regattas was the running account of the progress of the boat races, made by "radio reporters." This picture shows J. Andrew White talking into the microphone on the yacht "Elco," broadcasting through WJZ.

Long Distance Reception on Crystal Sets

LISTENING to programs broadcast from London through the long winter nights is the engaging prospect held out for owners of simple crystal sets, according to announcements made by the Radio Corporation that all arrangements have been completed for an exchange of British and American programs, at least several times a week and perhaps nightly. The music and speech will come from the new station at Daventry, seventy-five miles from London, be picked up at Belfast, Me., and retransmitted through the new WJZ station at New Brunswick, N. J., which is to be one hundred times as powerful as the present WJZ.

* * *

Californian Schools Use Broadcasting Regularly

EXPERIMENTS that have been carried on over a period of eight months at Oakland, California, have convinced the local educational authorities that radio broadcasting is of definite value in classroom instruction. Dr. Virgil E. Dickson, head of the department for "research and guidance" in the Oakland public schools, who is carrying on this experiment finds that the subjects best suited to broadcasting are penmanship and drawing; in drawing, particularly, radio has stimulated greater originality on the part of the pupil than has instruction that is given by the teacher in person. Entirely new fields of possibility have been opened by the experiments, and a new era of educational methods may result.

* * *

The Patron Saint of Radio Fans

THE automobilists have already chosen their patron saint, who is St. Christopher. But the radio enthusiasts have not yet designated theirs. The new French publication, "La T. S. F. pour Tous," is organizing a referendum among its readers in order to learn their opinion on this subject. The first results seem to be in favor of Joan of Arc.

WITH THE INVENTORS

CONDUCTED BY WILLIAM G. H. FINCH

THIS *department will keep you in touch with the latest inventions of interest on which patent rights have been granted, and which are significant contributions to radio art.*

A Novel Cone Loudspeaker

DR. HANS SCHARF of Berlin was granted patent No. 1,540,229 for a cone-shape loudspeaker.

In loudspeakers that employ the usual type of telephone receiver in combination with a horn, one drawback lies in the fact that not the entire surface of the diaphragm is exposed to the air. Furthermore, during its movement the diaphragm produces objectionable noises because it is rigidly held around its periphery.

In this invention these drawbacks are avoided by holding the diaphragm around its periphery in a manner that the diaphragm contacts only with some soft material, preferably rubber, and the whole surface of the diaphragm is exposed to the air.

The diaphragm disclosed in this invention moves practically freely in the air and substantially parallel with its normal position. This should result in improving the quality and quantity of the reproduced sound.

The soft material, *i.e.*, rubber used for holding the diaphragm, is preferably stretched over the whole surface of the diaphragm or it may be solidly connected therewith around its periphery. Due to this provision the vibration of the diaphragm will be materially damped.

In Figures 1 and 2 these features will be noted; also that the diaphragm is cone-shaped of metal; it is entirely covered with a piece of rubber cloth. This is a feature that is not found in domestic cone-type speakers.

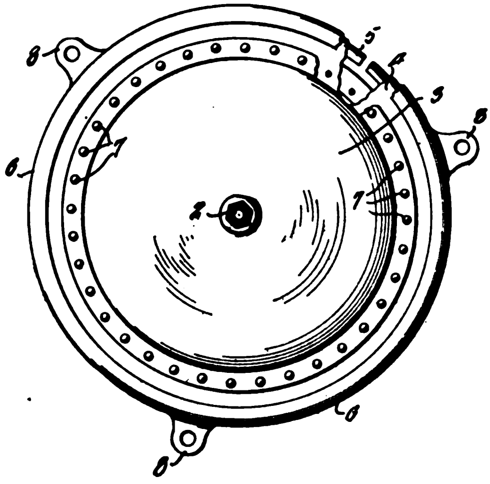


FIGURE 1: *Top view of Scharf loudspeaker in which a few details of construction are shown.*

A New Radio Receiving System

THE Commissioner of Patents recently allowed 56 claims to Oscar C. Roos of Boston, in letters patent No. 1,545,697 covering a very novel electrical acoustic method of reducing interference and static disturbances in radio phone receivers which possesses considerable merit.

The invention relates to broadcast receiving systems and more especially to such systems whereby the effect on the signal-indicating device of electrical vibrations created in the system by abrupt or impulsive electrical forces (such, for example, as "static disturbances" or electrical vibrations created in the system by interfering signal waves), is eliminated or reduced to a minimum so that the signal-interference ratio is a maximum.

Mr. Roos has discovered that the irregular non-musical noises or non-harmonious vibrations produced by a signal-indicating device, such as a telephone receiver when the receiving system is acted upon by abrupt or impulsive electrical forces, may be converted into spatialized periodic vibrations.

In carrying out the invention, he provides means for converting the electrical vibrations developed in the receiving system by abrupt or impulsive electrical forces. The electrical vibrations developed therein by the electromagnetic waves, the energy of which is to be received into dephased specialized non-electrical vibrations, such, for example, as sonorous vibrations produced in an air column, and an apparatus so associated with such means that the amplitude therein of the non-electrical vibrations resulting from the waves, the energy of which is to be received is large compared to the amplitude therein of the non-electrical vibrations resulting from the abrupt or impulsive electrical forces, and a signal-indicating device associated with said apparatus. The non-electrical vibrations which pass into the apparatus may be converted into electrical vibrations by any suitable means, and in such case a signal-indicating device is operatively connected with such means.

The invention comprises means for converting the irregular complex noises produced by a signal-indicating device (such as a telephone receiver) when the receiving system is acted upon by abrupt or impulsive electrical forces into well defined steady acoustic vibrations of any convenient pitch. This means consists, for example, of a resonant air chamber so designed that when the confined body of air therein is shocked into vibration at its own period, an acoustic vibration different in pitch from that of the signal will be produced, the pitch of which signal is under complete control of the operator by means of the heterodyne. The complex sound, consisting of the acoustic vibration produced by the signal waves and the non-musical noise produced by the electrical disturbance, which is introduced into the air chamber, will produce a resultant complex vibration which is the sum of its components, but which, when of audible pitch, is different in sound from either.

The invention also comprises a means for spatializing the two sound waves that make up the resultant acoustic vibration, such means being, for example, a resonant air-chamber of such dimensions that the two sets of vibrations will produce stationary sound waves. These, being of different frequencies, will be dephased. Means are provided for picking up the stationary sound waves produced by the signal waves at a point where the amplitude thereof is large compared to the amplitude of the stationary sound wave formed by the electrical disturbance; for example, at a pressure loop of the former and a pressure node of the latter.

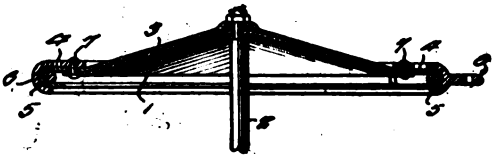


Figure 2: *Cross section view of the new Scharf cone-type of loudspeaker.*

Having separated two sets of sound waves and picked up a portion of the energy of the stationary sound wave formed by the signal vibrations, use may be made of it for producing the signal or one may employ apparatus such as a radio transmitter for reconverting such sound waves into electrical vibrations, and transmit the latter to a radio broadcast receiver. By transmission through several stationary-wave separating devices in succession, further separation of the signal and interference vibrations may be affected.

It is also contemplated to use a sound reflection or refraction device whereby the sonorous vibrations produced by the signal waves after separation from the sonorous vibrations produced by the electrical disturbances may be concentrated on the apparatus which reconverts them into electrical vibrations.

It will be obvious that the principle underlying the invention may be embodied in a great variety of apparatus and that various circuit arrangements may be employed in connection therewith for converting the energy of electromagnetic waves into sonorous vibrations at one end of the apparatus and for converting sonorous vibrations into readable signals at the other; and

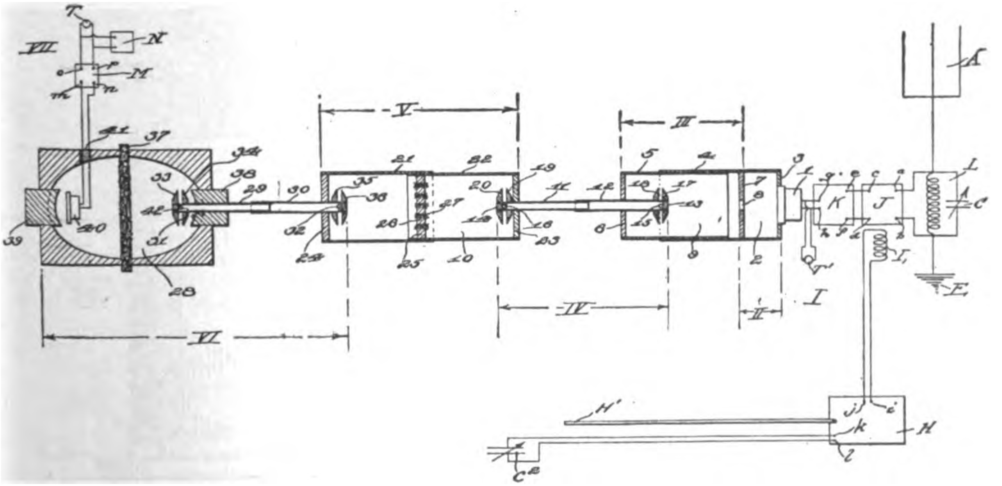


Figure 3: *A schematic diagram of the Roos radio receiving system. It is a very novel electrical acoustic means for reducing interference and static disturbances and possesses considerable merit.*

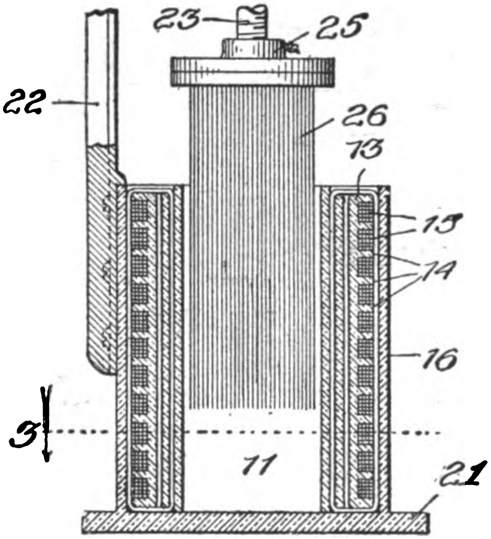


FIGURE 4: *This shows a cross section view of the Sandell radio frequency transformer; the movable feature of the iron core may be seen in the above diagram.*

therefore, it will be understood that the several embodiments of the invention described are illustrative merely and not restrictive.

A Radio Frequency Transformer

A NEW design in radio frequency transformers is shown in patent No. 1,541,398, issued to Henry K. Sandell of Chicago, Ill. It is particularly adapted to be used for radio frequency amplification in radio receiving sets.

A feature of this invention is the design (see Figures 4, 5 and 6) the construction of which provides a radio frequency transformer in which the iron core is movable and the de-saturation time of the iron is varied. By properly choosing the values this time may be brought into step or resonance with the natural period of inductance of the secondary coil.

The primary is aperiodic and the secondary is periodic or resonant for the present broadcasting frequency band. In other words, varying the iron in the core varies the frequency of the secondary coil so that by this means the resonance of the circuit in which the secondary coil is placed may be tuned. When this occurs the strength of current that flows in this coil is greatly increased. The relation between the soft iron core and the secondary is very sensitive to small changes in either, while relatively large changes in the primary are permissible without materially altering the operation of the transformer.

If desired short pieces of the soft iron wire may be embedded in a non-magnetic substance to form the movable core and by properly proportioning this the wires 12 (Figure 6) may be omitted altogether from the final design or assembly.

A New Crystal Detector

FERDINAND SCHNEIDER was recently granted U. S. Patent No. 1,549,926 for a new crystal detector.

His invention relates to that class of receiving devices for damped or undamped electric waves, on which a gap between electrodes is bridged over by means of a preferably spherical member of wave-reactive material, i.e., a crystalline substance which is responsive or sensitive to electric waves; for example, silicon, molybdenum glance, pyrites, carborundum or the like, said wave reactive member being subjected to pressure.

He has found that members composed of such wave-reactive material have not a uniform sensitiveness throughout, and therefore make these members movable along the electrode gap, preferably by means of rotation around their centers; this insures that the most sensitive points of the wave-reactive member or members can be brought in contact with the electrodes.

Another feature of the invention is that the

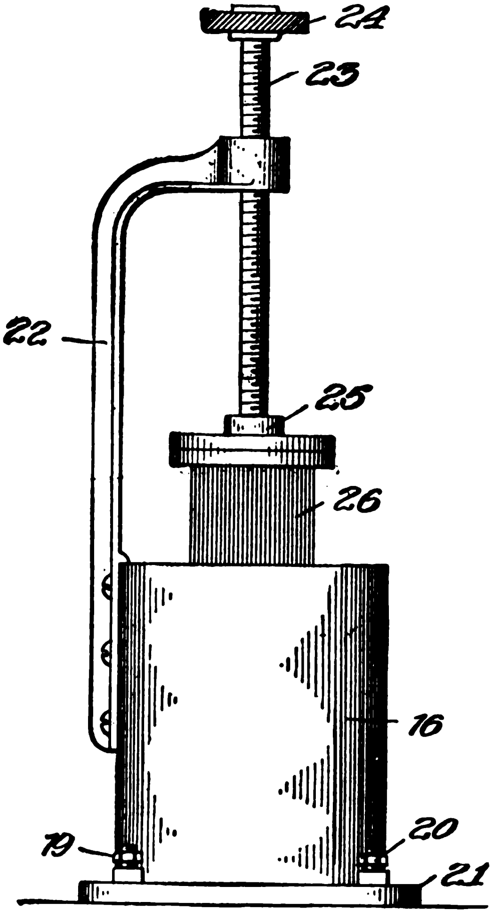


FIGURE 5: *Is another view of the Sandell transformer, completely assembled; in this diagram can be noted an important detail—the means for adjusting the iron core.*

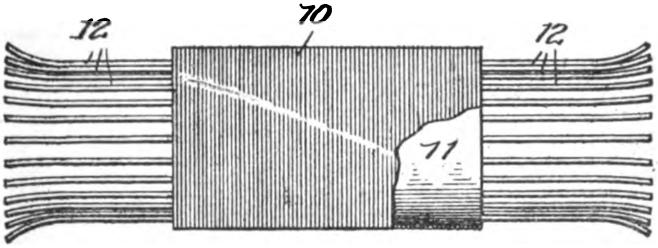


FIGURE 6: *This shows the iron core assembly.*

pressure exerted on the wave-reactive member or members is made adjustable so that the effect may be increased. By roughening the edges of the electrodes in contact with the wave-reactive member, or by bending electrodes of sheet metal, the inventor increases the number of points of contact and finally forms the wave-reactive member or members from the most wave-sensitive parts of the reactive substance, which he ascertained by previous experiment. By this means the specific resistance is considerably reduced, so that weak-current relays connected up can be used without the hitherto necessary intensifiers or extra sources of current, because speeches or sounds are received with a more powerful clear tone.

A New Vacuum Tube Socket

IN patent No. 1,547,729 issued to William T. Booth of Brooklyn, N. Y., is disclosed a new and improved form of tube socket structure to be used in vacuum tube sets and telegraphy and telephony.

An object is to provide an improved socket structure so that a socket in use with one form of set and adapted to be used with one type of tube, cannot be used with any other type of tube while in that particular use.

Another object is to so construct the socket structure that the new element added which constitues the invention, may be readily adapted to or removed from the socket structure.

In the ordinary vacuum tube socket the tube fits by means of a bayonet and lock-joint into the socket, the terminal plugs at its lower end slightly contacting with a plurality of terminal springs. In the ordinary tube these terminal plugs on the base of the tube are definitely positioned angularly with respect to the bayonet pin also on the base, and similarly the terminal springs on the socket are definitely positioned angularly with respect to the bayonet lock so that when the tube is in position definite terminal springs will contact with definite terminal plugs on the tube. In order to adapt a socket for use only with one type of tube, this invention comprises the provision of a plate of insulating material which is interposed in a plane between the terminal springs and the plane of the base of the tube when in position in the socket. This plate is provided with suitable apertures which are definitely placed angularly with respect to the bayonet slot of the particular socket to which it is adapted, so that the terminal plugs only of the tube which is to be used with this socket will properly fit the aperture in the above-mentioned insulating plate and thereby pass therethrough to make contact with the terminal springs.

A New Inductance Coil and Tuning Methods

FRANCIS DE WILLY of Los Angeles, Cal., was recently issued Letters patent No. 1,549,247 for improvement in "Inductance Coil and Tuning Methods." One of the objects of the invention is to provide a transformer for an electrical circuit or radio apparatus which is exceptionally efficient in operation in comparison with the present type of transformers.

Other objects of the invention, as set forth in the patent, are to provide a transformer operating to prevent re-radiation of energy from the receiving apparatus; operative to absorb or take up a maximum signal strength; operative to reduce the outside magnetic field around the transformer and thus eliminate undesired coupling with other units of the receiving system; and operative to provide a coupling for a radio apparatus tending to stabilize the action of the apparatus and to increase the range and signal strength.

Another object is to provide a simple form of detecting circuit for a wireless receiving set, operative to efficiently amplify signals received while providing a sharp tune and stable apparatus which may be constructed at a low cost.

A Cardinal's Impression of Radio

"BY common consent, radio is a force of immeasurable potency. It will unquestionably affect the history of humanity as electricity and steam and the printing press have affected it. We may say, in a certain sense, that radio surpasses these and other agencies, for it is able to influence millions of people scattered over the earth profoundly, instantaneously. It is one of the greatest powers that man has ever had in his hand."

—CARDINAL HAYES

LISTENING IN

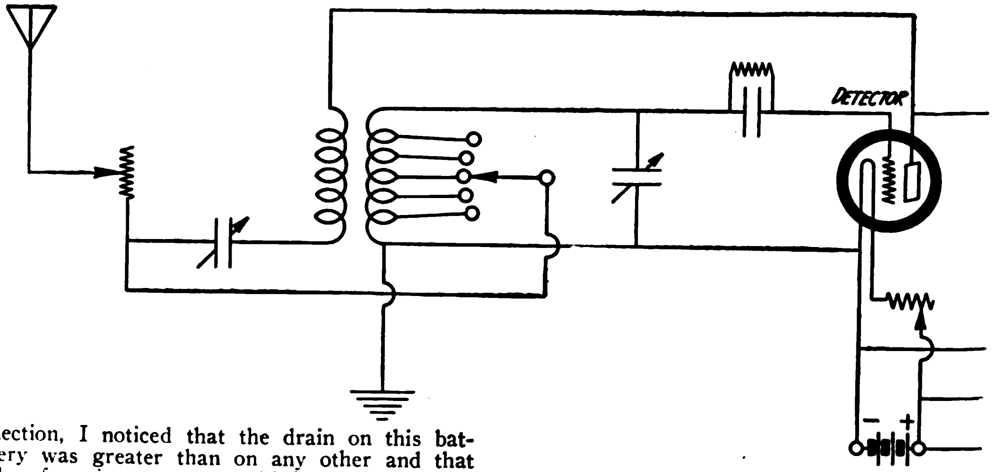
Practical *pointers from experimenters and broadcast listeners.. What helpful hints can* YOU *offer to your fellow fan? Readers are invited to address their letters to the editor of this Department.*

Conducted By Lloyd Jacquet

How to Avoid an Uneven Battery Drain

I notice that when my "B" batteries have reached the point of recharge, it is usually the first 45-volt battery that is discharged first.

A little curiosity enabled me to find out why this was. By studying the diagram of connection, I noticed that the drain on this battery was greater than on any other and that therefore its energy would be used up in a smaller unit of time, as compared with the other batteries.



THESE 22½ VOLTS ARE SUPPLIED BY A HALF OF THE FIRST 45 VOLT BATTERY ALREADY SUPPLYING 90 VOLTS TO THE AMPLIFIERS.

Indeed, I can see that besides supplying energy for the detector tube, through the tapping of the first 22½ volts, and being connected in the plate circuits of the amplifying tubes, this battery is being overloaded this much more. If the voltage is only 22½ perhaps the current drain is low, of the order of ½ milliampere or so. But a mistake is made when 45 volts are fed the detector tube, for the drain increases one hundred percent.

If you want to make the first "B" battery last as long as your other batteries, reduce the extra drain on it as much as you can by using minimum voltage of the detector tube, consistent with good results.

It might, in fact, be a good idea to change the position of the first and second sets of batteries occasionally.

—Ed Downing, *Brooklyn, N. Y.*

* * *

Short Waves On a Crystal Set

There are many short-wave broadcasting stations now operating which have programs just as interesting as the longer-wave stations. In fact, some of these short-wave programs are repetitions of the original broadcasts.

Most broadcast receivers are so designed that they will not tune below 250 meters. For those who are curious yet who do not feel as though they want to invest much money in the reception of short-wavelengths, the crystal set offers great possibilities.

A crystal receiver can be built with odds and ends about the house. Get a variable condenser, a discarded coil, and a crystal detector. The circuit can be completed by means of a few small fixed condensers. The hook-up is simplicity itself. One of them was given in Popular Radio for May, 1922.

Wind only 30 to 40 turns of wire on the coil. Use your present antenna if you so desire, although a shorter one would be better. Then, some evening when it is getting late, turn off your regular set for the crystal outfit and listen in. With the big stations using super-power, crystal reception is a possible thing within fifty to one hundred miles of the station.

—Harry Brande. *San Francisco, Cal.*

* * *

What I Found About Grid-leaks

Recently I had occasion to try out a friend's grid-leak for him, while he was building his own set, a one-tube affair. I noticed how much better his grid-leak operated than my own. I procured a new one, but it didn't function as well as that of my friend.

I bought one dozen of them, assorted in sizes. I tried every one of them, but with little difference in efficiency than the original one in my set. I found three or four of them, however, that really made a big difference in my receiver.

It has been my experience that grid-leaks are not always uniform, either in resistance reading, or in performance. Unless an excellent make is used, you can never be sure of the resistance value. This, however, has little to do actually with the actual performance of the unit.

Have a variety of grid-leaks on hand and experiment to find the best one. Not any old grid-leak will do. It is sometimes necessary to go through a bunch of them to get a few good ones. Buy only the best you can afford.

—C. Stevens, *Trenton, N. J.*

* * *

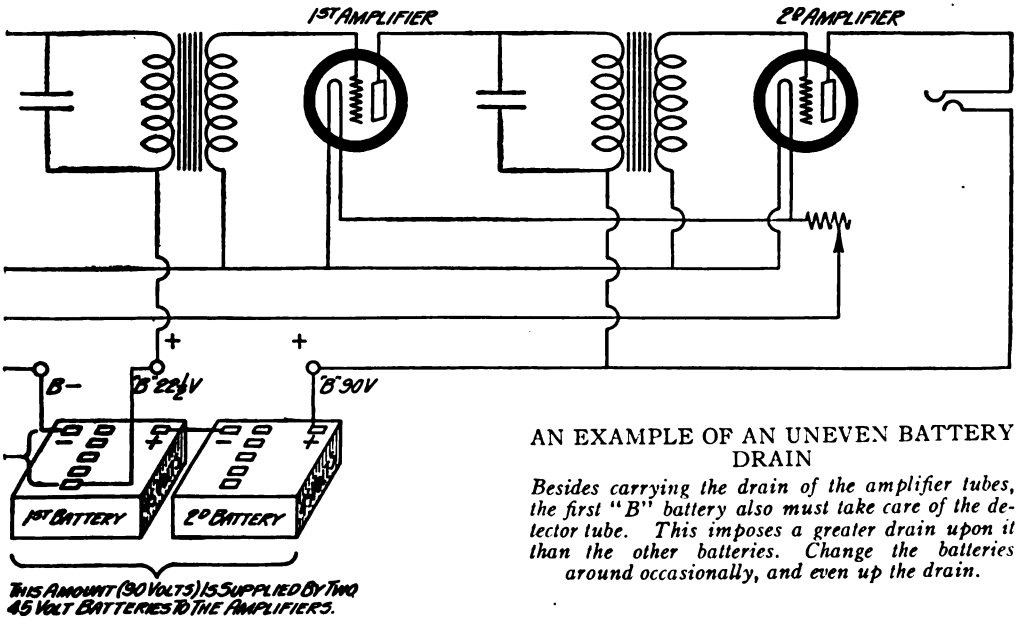
Fieldless Coils

I have already seen diagrams and articles referring to the use of the new types of coils, known as the "toroid," "doughnut," and other similar names, in which the constructor was shown to place these coils at right angles to each other.

In the old days of cardboard coils, inefficient condensers and leaky transformers, such precautions were imperative. But since these coils are supposed to be built to do away with the very nuisance that the writer of the article warns against, it isn't necessary to locate these coils at right angles to each other.

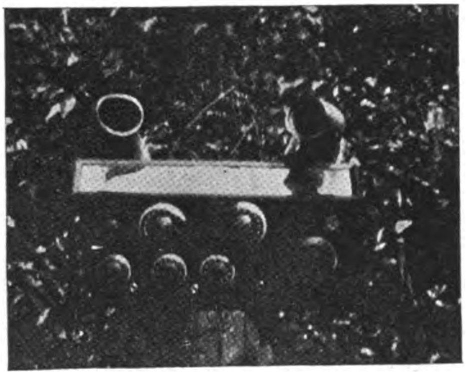
Such construction proves bulky and difficult in many cases, and nothing is achieved by it. It is of far more importance to remove from any winding the metallic masses of transformers, condensers and other units, which would create a real loss if placed too prominently in the electromagnetic field of a coil.

—John L. Sawyer, *Kansas City, Mo.*


1ST AMPLIFIER
2D AMPLIFIER
+
+
B−
"B" 22½V
"B" 90V
−
+
−
+
1ST BATTERY
2D BATTERY
THIS AMOUNT (90 VOLTS) IS SUPPLIED BY TWO 45 VOLT BATTERIES TO THE AMPLIFIERS.

AN EXAMPLE OF AN UNEVEN BATTERY DRAIN

Besides carrying the drain of the amplifier tubes, the first "B" battery also must take care of the detector tube. This imposes a greater drain upon it than the other batteries. Change the batteries around occasionally, and even up the drain.



COW HORNS AS LOUDSPEAKERS
These cow horns, fifteen inches in length, make up the loudspeaking part of this radio set. Even if they do look like periscopes, they add an odd tone to any radio installation.

* * *

A Novel Home-made Horn from the Farm

ALTHOUGH nearly every possibility for the design of radio loudspeakers has been thought of, here is a new idea that has many merits beside originality.

The cow horn, because of its very substance, is clear-toned, and solid. The making of a good loudspeaker unit for radio use out of a pair of cow horns is simplicity itself.

First secure a pair of horns; this will not be difficult if you live on a farm. Cut the tips of the horns off with a hack saw and at a point where the opening thus provided will fit into the hole of a telephone earpiece. By means of sealing wax or cement, the horns are fastened to the earpieces.

If the horns are big, like the ones shown in the illustration, the effect when the set is turned on will be most pleasing.

To add a touch of artistry, the interiors of the horns may be gilded, and a decorative rim placed on each. The horns work very well on this five-tube set.

—LOUIS YASSEN, *Chicago, Ill.*

* * *

How to Handle Glass in Your Set

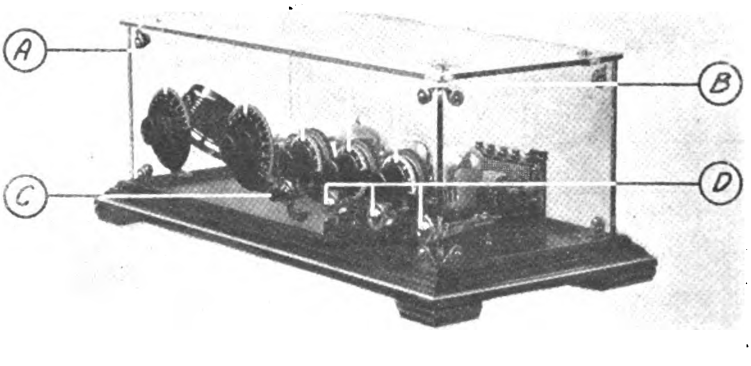
GLASS is being used to a large extent by experimenters who build radio sets. Because glass is such a good insulating material, it probably would be even more extensively used were it not for the fact that it is hard to work.

How to drill glass has already been told in POPULAR RADIO, but many set builders have had the experience of cracking a finished glass panel in the assembly of instruments.

Glass will not stand as much strain as other materials used in radio work, such as hard rubber, bakelite, fiber and others. But if the strain is eliminated or relieved there is less danger of breakage. One way to relieve this strain is by using care (when two or more mounting screws or nuts are located on a piece of apparatus) that one screw is not brought down tight first, and the others pulled up afterward.

When two or more screws or nuts are required for mounting a piece of radio apparatus, tighten up slightly on each screw or nut consecutively until all are brought up tight. This hint is good not only when working glass, but is advisable in any case where it is necessary to eliminate the possibility of strain or breakage.

—W. A. FRICKE, *Chicago, Ill.*



A HOME-MADE SET ENCLOSED IN A GLASS CASE
Glass is particularly attractive when it serves to enclose the components of a radio set. Here is the work of a Chicago firm, who can drill glass and prepare the holes with bushings for mounting the instrument without breakage.

Popular Radio

with which is combined The Wireless Age

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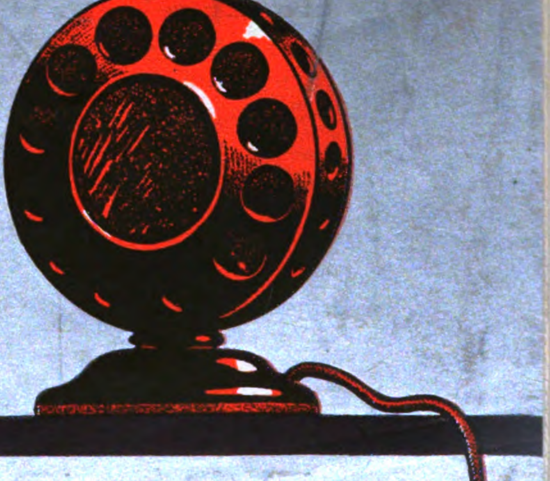

How to Build the New Orthophase Radio Receiver

silent power

...from your lighting socket

THE most rigid specification set for the Duo-Rectron, the new RCA "B" battery eliminator, was that it be silent—hum-free. The hum of the 110 volt, 50 or 60 cycle line current has been filtered out by a special filter system. And the perfection of this system is guarded by minutest care in manufacture.

In many important points the Duo-Rectron meets demands never met before.

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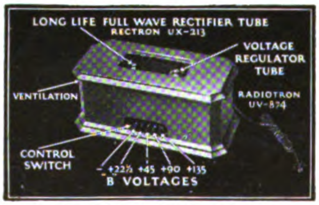

RCA Duo-Rectron, complete $65

The new rectifying tube, Radiotron UX-213, is built for long service—designed especially for this power unit.

Everything has been considered in the RCA Duo-Rectron — silent power, reserve power, economical power, constant power!

* * *

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RCA-Duo-Rectron

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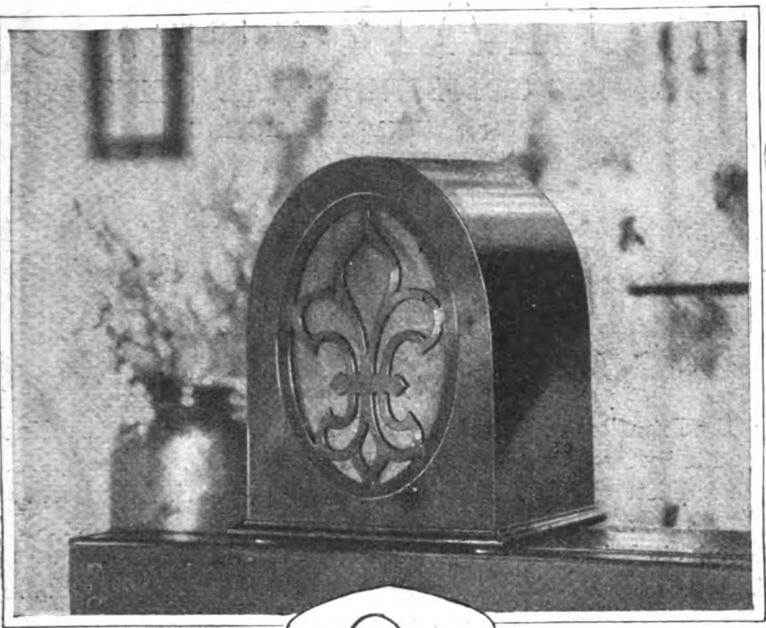

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The Type H—a simple horn of graceful lines and antique green and black finish. Great in volume—true in tone. Adjustable.

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Brandes

—experts in radio acoustics since 1908

POPULAR RADIO

WITH WHICH IS COMBINED "THE WIRELESS AGE"

EDITED *by* KENDALL BANNING

FOUNDED 1911

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(Cover design by Frank B. Masters)

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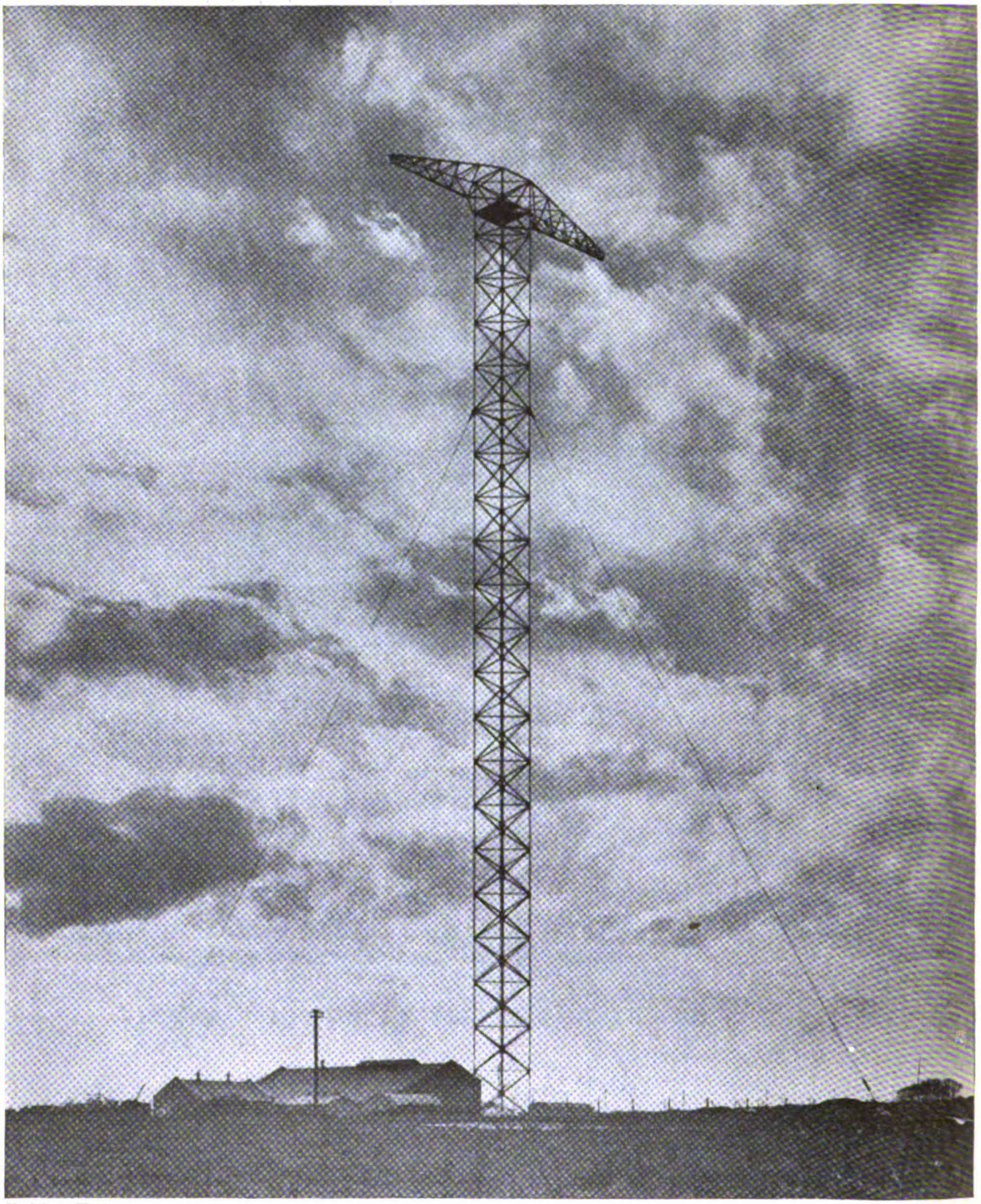


Kadel & Herbert

A Patrol On the Frontiers of World Peace

"I will make them one nation in the land."
—EZEKIEL 37:22

One by one a regiment of broadcasting stations is encircling the world; it now numbers about 800. The great part that these stations are destined to play in bringing the peoples of the earth into understanding is incalculable. This shows the powerful new station at Dorchester, England, which is figuring prominently in the present international broadcast tests.

Popular Radio

WITH WHICH IS COMBINED "THE WIRELESS AGE"

VOLUME IX FEBRUARY, 1926 NUMBER 2

Battling Bandits by Broadcasting

How the newly-developed radio apparatus with which the police are experimenting will add to the peril of fugitives—and the unique system of communication of which it is a part

By COL. RICHARD E. ENRIGHT

POLICE COMMISSIONER OF NEW YORK

A BANDIT raid had taken place in New York. A jewelry store had been broken into and the daring raiders had leaped into an automobile and had made an apparently successful dash from the scene of the crime.

But the bandits had reckoned without radio—the newest and most subtle agency in the hands of the law—when they had headed for the suburbs and supposed liberty.

Hardly had the bandit car disappeared when red lights flashed in police booths at every bridge and ferry in the city. Similar lights flashed and gongs rang in police booths in outlying parts of the city.

Through the municipal broadcasting station of the City of New York—Station WNYC—came the voice of a headquarters official, in even, unruffled tones, giving a description of the men and their car. At approximately two hundred places of strategic importance the word was received, for the alarm had been made general. Patrolmen were on the lookout everywhere. The capture of the bandits was effected at a bridge before the raiders had gone a mile from the scene of the robbery. In a few minutes the news of the capture was "on the air" and patrolmen went back to their beats.

For the purpose of meeting just such an emergency, which has been described in hypothetical form, the City of New York has taken a long step forward in the use of radio—a step which is almost revolutionary and which will be watched with interest by police officials in every other city in this country and abroad.

The International Police Conference held in New York, in May, 1925, got a demonstration of the possibilities of the city-wide system of radio alarm on which New York was then working and which, it is believed, will make an almost complete change in the method of communication between headquarters and outlying stations.

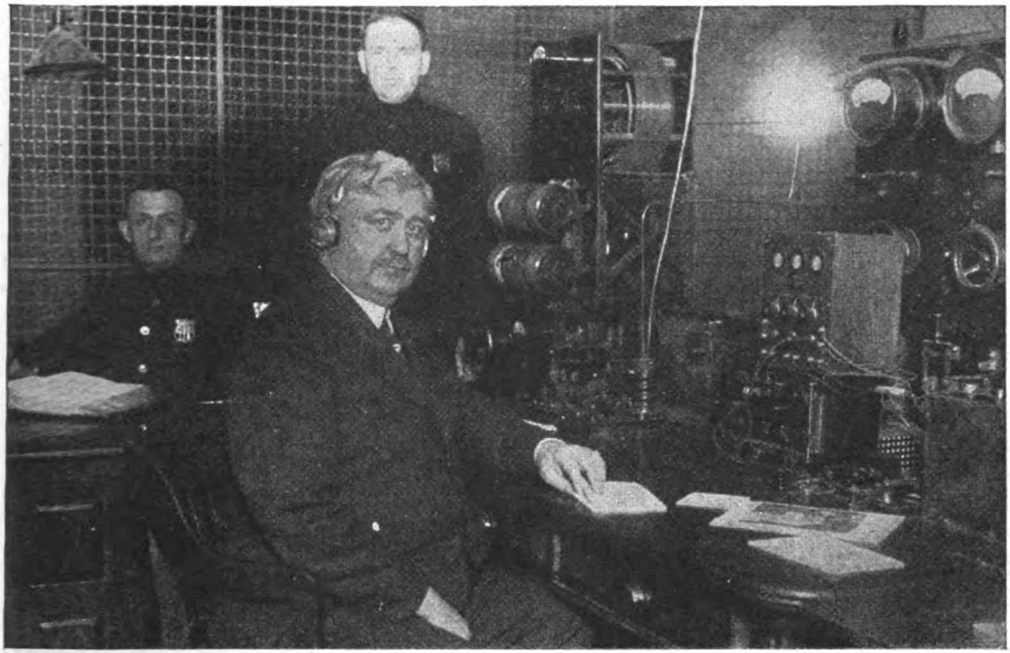
The visiting police chiefs saw a patrol box, in which was a new type of radio receiver with a green light burning, this light indicating that the power was on. Then a red light flashed and a gong rang, as summons to the patrolman. Through the receiver came a voice from police headquarters giving directions regarding a crime which was supposed to have been committed within the patrolman's precinct. The new device was given every possible test, and it met these tests satisfactorily. In fact, before the conference it had been tried out under adverse conditions, the most disadvantageous locations having been chosen, such as Far Rockaway, Long Island, Tottenville, S. I., and Northern Manhattan. Some difficulty was experienced in Northern Manhattan, owing to the effect of surrounding steel buildings, but all the tests were satisfactory, and New York's advanced step in criminal-catching by radio was pronounced the outstanding sensation of the police conference.

The hard-headed police chiefs who examined this new radio device and had it demonstrated in actual use, were not more impressed with its possibilities in the way of leading to the capture of criminals than by its promise as a factor in deterring crime. Anything that will make potential criminals think twice before committing a crime is indeed welcome. The automobile would be a wonderful deterrent of crime if the motors were in the hands of the police alone. But all the new devices which have meant speed in transportation have been effectively used by criminals as well as by officers of the law, and the gift of the gasoline motor must be regarded no better than a fifty-fifty proposition when it comes to crime prevention. Radio, however, is something that lends itself absolutely to police control. With radio police booths scattered

International

CAUGHT IN THE RADIO NET

With the aid of the new type of radio receiver developed for the special use of the police, the efficiency of the system of alarm employed by the New York forces of law enforcement are expected to be largely increased—particularly in the arrest of lawbreakers who seek escape via the public highways.



International

THE POLICE COMMISSIONER AT HEADQUARTERS

The installation of this broadcasting apparatus by the Police Department of New York has led to many applications of radio for the apprehension of law-breakers; this article tells of the latest.

about a city's outlying sections, what criminal is not going to take them into account before committing a crime?

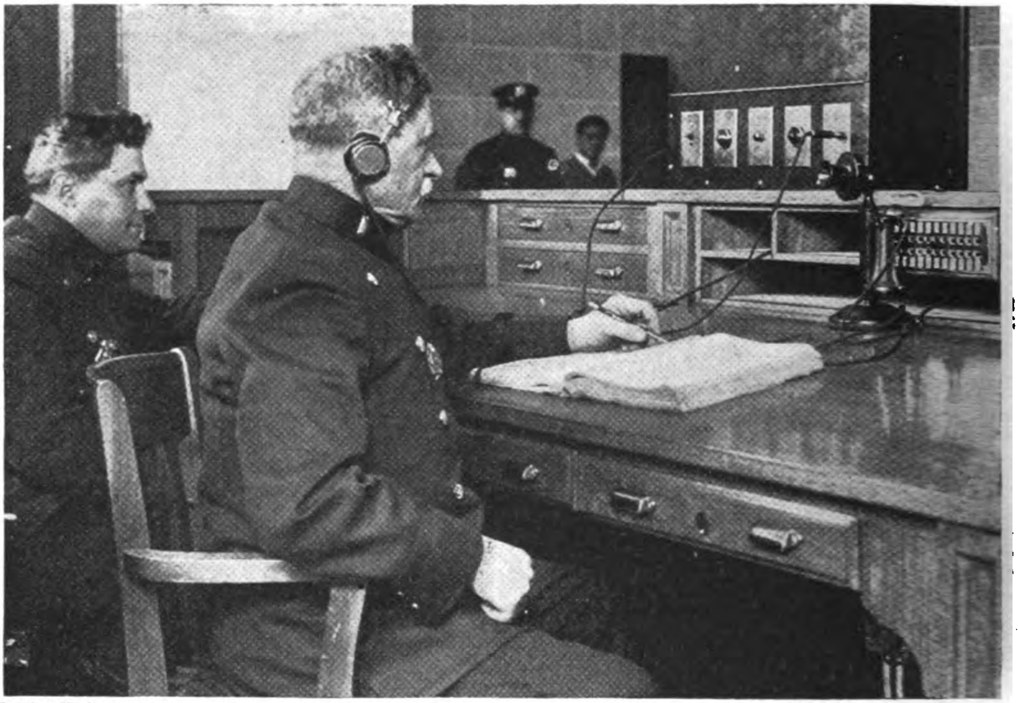
For covering strategic points, radio is looked upon as ideal. The criminal, after the commission of his crime, seeks the ordinary avenues of escape,—generally the railroads. If he knows there is a radio police booth at every station, he will be a poor general if he does not take them into account. If he plans to avoid the railroads and escape to the country through the suburbs, there are the suburban radio receiving stations to be taken into account. Then there are the radio stations at bridges and ferries—in fact a complete net thrown about the city, with hundreds of ears listening simultaneously to the instructions from headquarters: "Here is a description of your man—now get him."

Furthermore there is the fact that, in case of a general alarm, every individual who owns a radio set may listen in and be on the lookout for the criminal.

These are the things which, it is predicted, will make radio a real crime deterrent. Criminals, when once they understand the working of this new agency that has been brought into effect against them, will give a wide berth to any city that is protected by a system of radio alarm.

How does this new form of police protection work, and how was it developed?

For many months the City of New York has been sending police alarms over its new broadcasting station, WNYC, located in the Municipal Building. These so-called alarms have generally taken the form of descriptions of missing persons and stolen automobiles. The success of this experiment led me to the belief that the use of radio in the department might be extended. Plans were worked out by S. E. Anderson and his associates in the Bell Telephone Laboratories, according to which the Western Electric constructed 186 receiving sets, which will be placed at various vantage points in Greater New



Kadel & Herbert

WATCHING FOR THE RED LAMP TO LIGHT ON THE RECEIVER AS THE—

When the red light flashes the police station's "number" is being called by the central transmitter, so that a message may be delivered. Each receiver is sharply tuned to a 3000 cycle tone, but it is so adjusted that its light flashes only when its own signal is called. This receiving apparatus was installed at a Brooklyn station house as a part of the new selective radio signal system of the New York Police Department.

York before the publication of this article.

The receivers are of fine quality and so designed that one booth may be signaled singly. If so desired, a group of booths may be signaled, or a general alarm will reach all simultaneously. At headquarters there is a simple box, which, with a turn of the signaling key, is set for the desired stations. The operator at headquarters sends a signal to WNYC, and the police call goes out on the regular wavelength of that station. This call can be heard by all who are "listening in" on WNYC. If it is desired to keep the police information secret, the call may be sent out in code. Thus the radio listener, who finds his program shut off, may catch such unintelligible words as "Brazil sugar preferred whales ships broadaxes," and will know that a police message of the utmost importance is being sent out. As a rule, however, the instructions will be broadcast without regard to code.

Suppose it is desired to get word to a patrolman at Bayside. His booth is signaled and the impulse turns on a red light and rings a gong. The red light will continue to burn and the gong to ring until the patrolman answers.

The basis of the system is the Western Electric railroad selective telephone train dispatching system now in general use on railroads in this country and in Europe. For every division these systems consist ordinarily of a single line to which are connected a number of stations capable of being called by the dispatcher individually or in groups. It was felt that such a system was adapted to radio transmission and would permit broadcasting from a central radio transmitting station without requiring the constant attention of opera-

Kadel & Herbert

—OPERATOR SENDS A WARNING ON THE TRANSMITTING APPARATUS

A set of six small levers which move up and down in their respective slots operate the transmitter. Each slot is provided with a number of stops which are designated with a letter or number; when the levers are set at the combination of letters and numbers which forms the "call" of an individual police station the signal is sent out automatically from the broadcaster WNYC. Any station may be called separately or all the stations may be called at once.

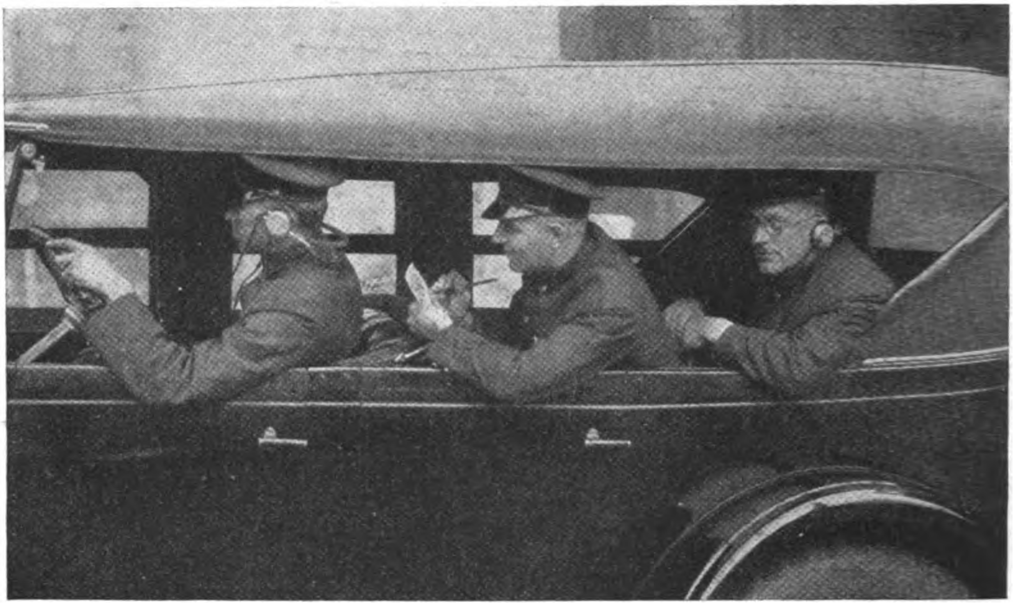
tors at the receiving stations.

The transmitter attachment consists of a vacuum tube oscillator tuned to approximately 3,000 cycles, and a number of calling keys. These keys control a relay whose contacts short circuit the plate windings of the oscillator coil when in the normal or unoperated position.

Operating any of the calling keys opens and closes its contacts in a regular sequence determined by the code for which the key is set. Each of the individual keys is set to a certain code call, which it will continue to make until reset. One of the individual call keys is used as a master call for the entire system, so that by the operation of this key every receiver is called simultaneously. The other four keys are for the main group calls. The master key is similar in appearance to a miniature cash register, and, by setting its levers to the proper code combinations, any desired station may be called individually on this key, which may be used also for some of the group and sub-group combinations.

The output terminals of the oscillator of the transmitter attachment may be connected directly to the speech input equipment of a standard radio telephone transmitter in place of a microphone. The sensitiveness of the radio receiver is adjusted for the reliable operation of the signaling system, which is sharply tuned to a 3,000-cycle tone. Even should the signaling system relays be operated occasionally by excessive volume of speech or music, the receiver signal lamp will not light unless the proper code call is sent.

The receiver apparatus is designed in



TAKING TEST ORDERS FROM HEADQUARTERS IN A RADIO-EQUIPPED CAR

To enable the police to keep in touch with headquarters even while on the trail of their man, this automobile has been equipped with a radio set by the Cleveland Department of Public Safety. Later it expects to equip all ten of the Police Reserve Squads with radio receivers and to install a broadcasting station at headquarters.

two types, one for each kind of power supply. A green signal lamp will light only when the power is turned on. Both the DC and AC types of radio receivers are designed for operation from an open antenna. All the controls are on a panel inside the receiver and are inaccessible when the receiver cabinet is locked.

The selector is the heart of the signaling system. It consists of a mechanism unit mounted on a magnet unit, the whole enclosed in a glass case for protection. All the transmitting keys are so arranged that one second after the completion of their calling signal, they send out a signal which restores all selectors under their control to normal. An audible signal may be connected, using an additional relay necessary to handle the heavy current required by a large gong.

A key is used by the policeman to extinguish the red signal lamp when he takes up the head telephones. To the right of the key is the green signal lamp, indicating that the power is on the receiver, and on the extreme right is a switch for turning power on and off.

The apparatus is readily portable. It will be impossible for anyone to tamper with the set when it is locked in the patrol booth. With no wires to cut, it will be impossible for lawbreakers to keep the patrolman from connection with headquarters. Not alone is the radio system of police communication regarded as a certain deterrent of crime, but its possibilities in the way of life-saving are not to be overlooked. In case of an accident, where quick communication with a patrolman from headquarters is necessary, the radio system is looked upon as ideal. Also it is felt that it will add to the security of residents in outlying districts of the city.

The radio telephone will be an important adjunct to the radio telegraph, which has been in effective use by the police department of the City of New York since 1918. At headquarters a radio telegraph operator is on duty day and night. He is prepared for any call that may indicate an emergency.

If an injured person is being brought in on a ship, a call can be sent when the vessel is within 250 to 300 miles of the port of New York, and an ambulance will be in waiting at the dock. Or, if officials are bringing in a prisoner of importance and it is desired to have an extra guard when landing, a call is sent to police headquarters before the ship reaches port, and as many detectives as are necessary are at hand when the gangplank is lowered. In case of any disaster to a ship within reasonable radio distance of the port, police headquarters is ready to send assistance. Much of the work is keeping in touch with police and fire boats. The following record, which is published for the first time, is interesting, showing as it does the large part radio plays in the activities in and around New York Harbor:

The total number of calls sent and received from June 3, 1924, to June 3, 1925, 12,767, classified as follows:

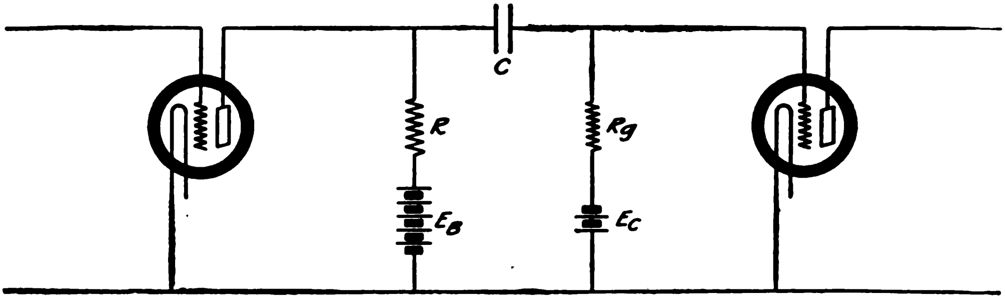
Mayor's Committee, steamer *Macon*	800
Steamer *Manhattan*, Police Department	10,500
From other stations, shore to ship	60
Ship to shore	50
Suspicious boats	1,000
Ambulance cases	5
Transmitted and received for city officials	150
Derelicts	10
For Federal Government	5
Distress	25
Shooting on steamers	3
Calls for assistance	25
Boats on fire	11
Fallen airplanes	4
Bodies recovered	100
Assaults on steamers	12
Automobiles overboard	5
Lost boys	2

It is estimated that it will cost about $50,000 to equip the City of New York with the radio telephone system which is being installed in the outlying districts and points of strategic vantage. The successful working of this system, which has responded favorably to every preliminary test, will mean that other large cities throughout the world will follow New York's lead and that lawbreakers everywhere will find in radio a new and baffling agency, making crime just so much more difficult to "get away with."

Any agency or device that makes crime more difficult has a distinct value in police work. The radio telephone should not only make crime more difficult but, through the publicity it must inevitably give the subject of police surveillance and activity and the punishment of crime and criminals, it can become a moral force and a promoter of law and order without a peer. The Police Department has made a systematic effort, throughout my administration, to secure vigorous and sincere co-operation from every decent, law-abiding citizen and everybody or organization in the suppression of crime, and there is every reason to believe that the radio telephone will render exceptional service in the accomplishment of this purpose. Those in charge of broadcasting equipment should bear this in mind and also, that a heavy responsibility rests on them in regard to the promotion of it. The potentialities of the radio telephone are almost limitless and the next few years will no doubt see some very startling developments in it. One of its principal fields of usefulness must always be in the dissemination of police intelligence, and it is to be sincerely hoped that this marvelous device will always be in the hands of those devoted to public service and the common good.

How to Build a Receiver for Both Short and Long Waves

ANOTHER *constructional article—prepared by the* POPULAR RADIO *Laboratory—of particular value and interest to the radio experimenter, will appear in this magazine next month.*



THE FUNDAMENTAL DIAGRAM OF RESISTANCE COUPLED AMPLIFIERS

This shows a skeleton circuit of the type of amplifier discussed throughout this article. The coupling resistance is shown at R; E_B *is the "B" battery, C the coupling condenser,* R_g *the grid-leak and* E_c *the grid biasing battery. The "A" battery circuit has been omitted since if all connections are made to the negative "A" battery this circuit does not affect the external circuits and serves only to heat the filament.*

HOW TO REDUCE DISTORTION IN AMPLIFICATION

PART I

THIS series of articles has been prepared for the special benefit of the average fan who likes to build his own receiver but who is discouraged by the usual distortion in reception. As most of this distortion occurs in the audio-frequency amplifier, these articles will concentrate on this phase of the problem. This first article in the series is a study of tube problems and of resistance coupling methods of amplification.

By HUGH S. KNOWLES

WITH the passing of the novelty of radio reception an insistent demand for good reproduction has come from all classes of listeners-in.

Engineers are carrying on intensive research work in an attempt to satisfy this requirement. Those who design our transmitting stations have done so well that any good broadcasting station today transmits signals which are almost perfectly modulated.

The perfection of the receiving and reproducing apparatus has lagged far behind that of the transmitter. This is especially true of the receivers built by the average fan who has only a meager knowledge of receiver design to call upon.

Most of the distortion in receivers occurs in the audio-frequency amplifier which amplifies the weak, rectified, audible signals delivered by the detector. Further distortion occurs in the loudspeaker but this is minimized in the best ones now on the market. It is possible that a more complete understanding of the problems of amplification will enable the experimenter to minimize the distortion occurring in his present receiver and aid him in the design of new ones.

By dividing the problems encountered in the different types of amplification and presenting each more completely the author hopes to present some problems which have previously been underemphasized, primarily because of lack of space and the attempt by authors to cover too much in one article.

The problems will be taken up progressively from the point where an undistorted signal current is applied to the input of a vacuum tube, through the tube, the interstage coupling device and to the input of the next tube in a cascade amplifier.

For the sake of brevity and clarity the more common abbreviations have been used in discussing the vacuum tube and its associated circuits.*

Figure 1 shows a vacuum tube. In addition to the usual elements three capacities and two resistances are shown. The capacities exist because of the adjacent tube elements. The various elements are comparable to small plates of a condenser. Generally these capacities are very small and may be neglected but under certain conditions which will be investigated later they are important.

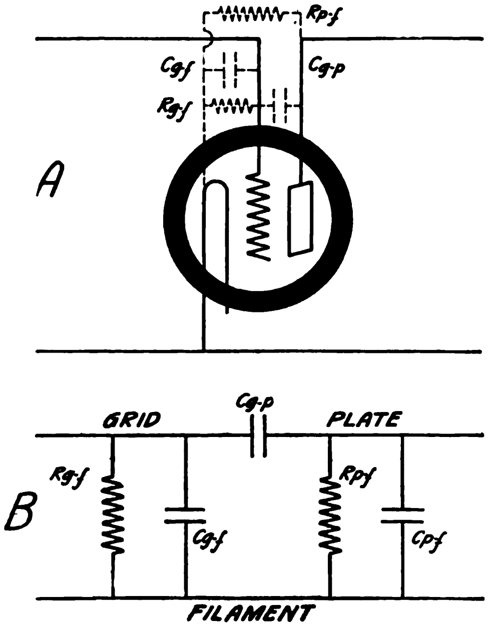
There is normally a flow of electrons from the filament to the plate and under certain conditions to be mentioned the grid intercepts some of them. Work is done in moving them, therefore some electrical resistance exists between the electrodes. The resistance between the electrodes of the tube and between the binding posts in the socket will be high enough to be negligible if the tube and socket are properly designed so they are neglected for our purpose.

When the grid of a vacuum tube is negatively charged it repels the electrons, as they are small quantities of negative electricity and like charges repel. The flow of electrons from the filament to the grid is therefore negligible, or what is the same thing the resistance between the two is very high—approaching infinity.

Potentials or voltages are said to be higher as they become more positive. In a tube the point of lowest potential in the filament, which is emitting electrons, is used as a convenient reference point and all potentials are referred to it. The grid, for example, is said to be at O potential when it is connected to the negative filament terminal.

As the potential of the grid is increased it begins to attract electrons. This attraction increases rapidly with an increase in the grid voltage. Put differently, the resistance from the filament to the grid decreases rapidly with slight increases in grid potential after a certain point.

This effect is shown graphically in Figure 2. Curve B is for a low mu tube of the 201-a type. After the grid becomes more than about 3 volts posi-



TWO DIAGRAMS OF A VACUUM TUBE

FIGURE 1: *The upper diagram shows a tube as it is usually drawn, together with the inter-electrode capacities and resistances (except the grid to plate resistance). The lower is the theoretical equivalent of the upper.*

---

*See Appendix (a)

tive the grid current rises rapidly. The resistance from grid to filament can be easily calculated by Ohm's law.

$$R = \frac{E}{I} \qquad (1)$$

where R is the resistance called $R_{g\text{-}f}$ in Figure 1, E is the actual grid voltage E_g, and I is I_g or the grid current. I_g in Figure 2 is given in microamperes or millionths of an ampere.

Curve A is the same type of curve for a mu 20 tube. The mu of a tube is roughly a measure of its ability to control the electron stream from the filament to the plate.* In a high mu tube this greater control is obtained by making the grid mesh finer, the grid wire larger and by placing it where it most effectively controls the flow of electrons. We would then expect it to intercept more electrons at a given potential than the grid of a low mu tube.

This is clearly shown in the curve. The values of I_g at the left *must be multiplied by ten* to get the proper value for curve A. For convenience they were plotted on the same sheet. When E_c equals 2 volts positive, for example, I_g is about 136 microamperes. Multiplying by ten this gives 1,360 microamperes which if plotted on the same scale as curve B would be off the top of the sheet. This gives a value of $R_{g\text{-}f}$ of only 1,470 *ohms which is in shunt to the input.*

In one corner of the chart the circuit employed in obtaining the curve is shown. This will be given for all curves. Note that there is no resistance in the grid circuit except that of the microammeter which is negligible compared to the grid-filament resistance.

If there were a resistance R_{in} in this circuit and a current I_g flowed through it by Ohm's law there would be a voltage drop in it given by

$$E = R_{in} I_g \qquad (1a)$$

where E is the voltage drop, R_n the input circuit resistance and I_g the grid current. The voltage E_g actually applied to the grid would then be less than E_c by an amount $R_{in} I_g$ as obtained from (1a). In the setup used for Figure 2 as shown on the graph this resistance was negligible hence although I_g reached quite high values R_{in} being negligible made the product of the two negligible. In this case E_g equalled E_c.

Normally there is a high resistance in the grid circuit. When this is true any grid current causes a drop in the potential applied to the grid and decreases in turn the amplification. Especially in the last stage of amplification variations in grid potential of eight or ten volts are not uncommon and they average several volts.

The type of distortion secured is shown in Figure 3 where A is the input signal applied to a grid having no bias. This is generally the case in resistance, coupled amplifiers -since the negative bias obtained by the use of a coupling condenser and leak is very small. On the negative half of the cycle there is no distortion, as the grid current is negligible. On the positive half, however, the peaks are cut off, due to the drop through the input circuit resistance R_{in} with consequent distortion and introduction of harmonics.

An inspection of curves A and B in Figure 2 shows that it is *especially* imperative that the grid of a high mu tube never go positive.

We have then the first requirement for distortionless amplification: that the grid of the tube *should never go positive.* This is then the upper limit of the potential which should be applied to the grid. Later we will find the lower limit, the difference giving us the variation in grid voltage which can be used without distortion of the output.

Figure 4 gives a series of curves of the relation of the plate current to the grid voltage in a vacuum tube of the 201-a type with different values of resistance R in the output or plate cir-

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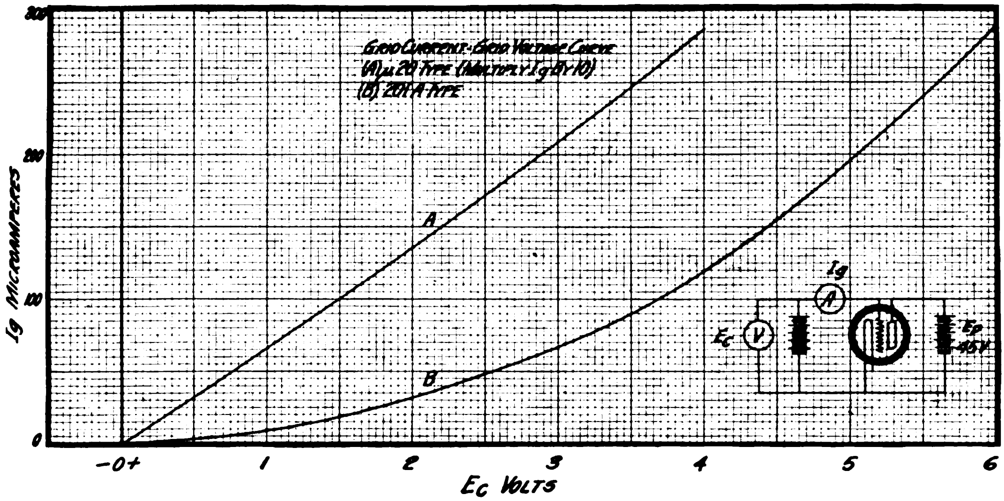
*See Appendix (b)



CURVES THAT SHOW THE RELATION BETWEEN THE GRID VOLTAGE AND GRID CURRENT

FIGURE 2: *This relationship as it occurs in an amplifying tube. Curve A is for a typical mu 20 tube and B for a mu 7.8 tube. The values of I_g for curve A should be multiplied by 10. If curve A had been plotted with the same co-ordinates as B it would have gone off the top of the graph at only .45 volts positive on the grid.*

cuit. Curve A is made with negligible resistance in the output circuit and is the static curve usually given in discussing the amplifying properties of a tube. The formula for the relation between the two clearly shows that although there is a portion which appears to be linear, actually only a *very small* part may be considered linear.* Only the portion of the following curves below 0 grid bias should be considered in view of what we have found above.

It is important that the portion of these curves below $E_g = 0$ be a straight line for distortionless amplification. This follows from the fact that currents of varying amplitudes must be amplified proportionally. If the curve were a parabola for example and a signal of 2 volts were applied to the grid the amplified signal would have an amplitude of 4 units and if one of 3 volts were applied the amplified signal would be 9 units. The ratio of 2 to 3 is higher than the ratio of 4 to 9 and loud signals would be overamplified. The curve A is more nearly a parabola than a straight line and it is evident that the tube itself is a distorting device. Fortunately by adjusting the associated circuits it can be made to amplify almost without distortion.

Curves B to G in Figure 4 are dynamic curves which show the relation of the plate current to grid voltage of a tube with some resistance in the output circuit which is normally the case. As the resistance R approaches 12,000 — 15,000 ohms, which is the approximate plate resistance R_p of the tube, a portion of the curve becomes linear. When R is 40,000 ohms the curve is substantially straight down to $E_g = -12$ volts. The fact that the slope or steepness of these curves decreases as R is increased does not indicate that the tube becomes a less efficient amplifier. Actually it will be found that curve G gives the highest voltage amplification. The graphical method of representing amplification has not been used because in such a case the slope of the curve has to be increased to give the desired impression.

The fact that the greater portion of the curves in Figure 4 become linear as R is increased is very significant since it is this fact that permits distortionless amplification. We will investigate it more fully later.

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*See Appendix (c)

In Figure 1 there is a resistance $R_{f\text{-}p}$ which has been so named to indicate it is the resistance in the tube from the filament to the plate. We will call this R_p when referring to its resistance to direct currents and r_p when referring to alternating currents. If this resistance were of the ordinary type the current through it would be proportional to the voltage across it and it would follow Ohm's law previously given. If, say, ten volts were applied and a current of one ampere flowed then two amperes would flow if twenty volts were applied. If we keep all of the variables in a vacuum tube constant and vary the voltage Ep actually applied to the plate (not necessarily the "B" voltage) and measure the corresponding changes in plate current we find a curve of the result closely resembles curve A in Figure 4. Using equation (1) we can calculate R_p from such a curve. The relation between the plate resistance and plate voltage is shown in Figure 5. These curves show that as the plate voltage is decreased the plate resistance rises rapidly.

If a resistance R is introduced in the plate circuit the voltage E_p on the plate will be less than the "B" voltage by an amount equal to the drop through R computed by equation (1a). This is analagous to what occurs in the grid circuit under similar conditions and I_p is used instead of I_g and R instead of R_n. The whole expression for the voltage on the plate under static conditions then is

$$E_p = E_B - RI_p \qquad (2)^*$$

Returning to the effect of the introduction of R in the plate circuit, we find it convenient to study its effect when R_p is constant. As Figure 5 shows this is done by keeping E_p constant. In Figure 6 therefore E_B has been increased after every increase in R until E_p was 90. These measurements were made with a 201-a type tube and curve A Figure 5 shows that for $E_p = 90$, R_p is approximately 13,500 ohms.

It is here very evident that as the resistance is increased the curve becomes linear over a very considerable portion. When R was 39,000 ohms the curve was linear to — 28 volts on the grid which means that distortionless amplification could be obtained on this portion. By operating with a negative bias of 14 volts a signal having a peak voltage of 14 could be amplified without distortion. In practice 410 for E_B is prohibitive and subsequent considerations will show that higher values of R should be used and that E_B can be less.

From our dynamic curves it is possible to find the amplification that can be obtained and its character. From Figures 4, 6, 7 and 8 we can find the change in plate current which takes place with a given change in E_g and for the approximate value of R we are using. If we obtain the variation in drop across R with

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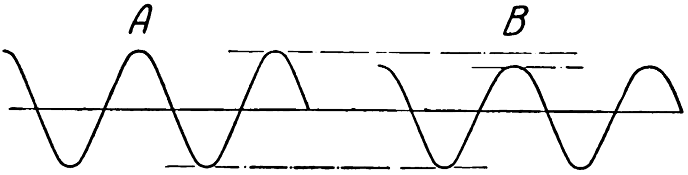
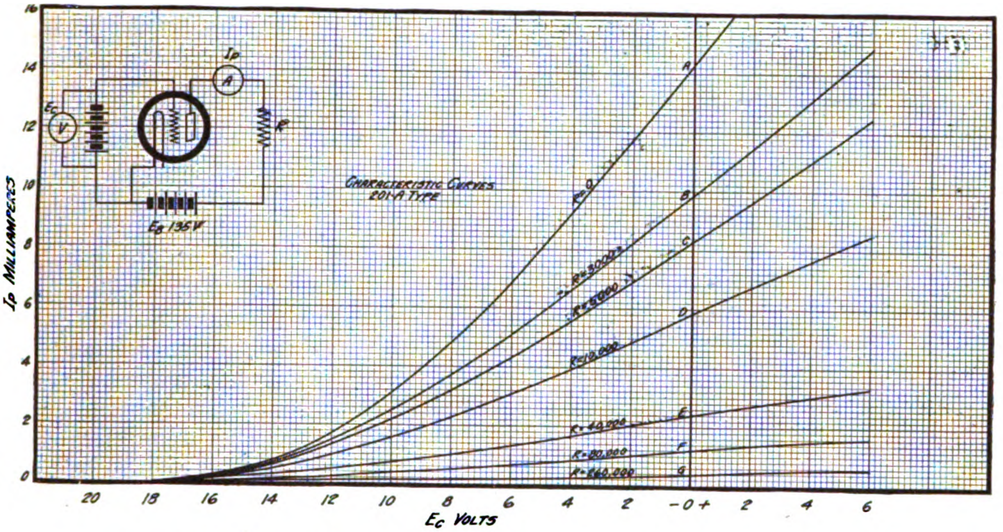
*See Appendix (d)



HOW DISTORTION IS CAUSED IN A GRID WITHOUT A NEGATIVE BIAS

FIGURE 3: *Curve A shows the incoming undistorted signal which is applied to a grid with no bias. On the positive half of the cycle the grid becomes positive and attracts electrons thus lowering the grid to filament resistance. The effect of this on the wave form is shown in curve B, where the positive half has been distorted with consequent introduction of harmonics.*



THE EFFECT OF VARYING RESISTANCES IN THE PLATE CIRCUIT

FIGURE 4: *This family of curves shows the relation between the plate current and grid voltage in an amplifying tube that has varying amounts of resistance in the plate circuit. A skeleton circuit on each graph in this article shows the method employed in obtaining it.*

variations in E_g we can determine the amplification, since this drop is what is applied to the grid of the next tube and the ratio of the two is the amplification per stage, assuming all of it is applied to the next grid. See the amplifier diagram for a characteristic circuit of this type.

Let E_g' be the voltage applied to the input of the second tube.

If an alternating current voltage e_g is applied to the grid of the first tube there will be a variation in the plate current i_p. The product of this times R (commonly called the coupling resistance) gives the alternating current voltage drop across R (if the resistance is non-inductive).

It is now evident that the amplification is distortionless when the tube is operated on a linear portion of the I_p-E_g curve because the variations in I_p are proportional to E_g. And since R is constant I_pR is proportional to E_g. Also it indicates that the amplification of curve G Figure 4 may be greater than that of curve F. The variations of I_p with E_g are greater in F than in G but in the latter case these variations have to be multiplied by 260,000 and in the former by 80,000 to secure E_g'. We will temporarily disregard C and R_g in the amplifier diagram and assume all of this drop is applied to the grid of the second tube.

The amplification per stage is given by

$$A = \frac{\mu R}{r_p + R} \qquad (3)^*$$

where A is the amplification, μ the mu of the tube, R the resistance of the coupling resistance and rp the alternating current plate resistance which may be considered to be half the direct current resistance in a high mu stage. In the average low mu stage r_p is approximately .8 R_p.* This formula assumes that all of the drop in R is applied to the grid of the following tube which, as will be shown later, is not always the case.

To familiarize the reader with the use of this formula it may be well to solve a typical problem. Assume that we are using a 201-a type tube with a mu of 10. This value is taken primarily for simplicity although some of the independent tubes have approximately this value. The coupling resistance has a value of .12 megohm or 120,000 ohms (this one was supposed to be .1 megohm). A milliameter was put in the plate circuit of the tube and the current was found to be .86 milliampere. This value could be predicted by examining curve C in Figure 7, which shows that for zero grid bias .86 milliampere flows in the plate circuit when a 135 volt "B" battery is used. The grid will be at approximately this voltage since curve B, Figure 3 shows that negligible current flows in the grid circuit. There will, therefore, be a negligible drop in the grid-leak, and the grid will be at approximately zero potential. From equation (2) we find that $E_p = 135 - 120{,}000 \times .00086$ or 32 volts. From Figure 5 curve A, which is for this type tube, we find that R_p is approximately 34,500 ohms when E_p is 32 volts. We have said that r_p is approximately $\frac{R_p}{2}$ so it will be about 17,250 ohms in this case. Substituting these values in (3)

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* See Appendix (e).

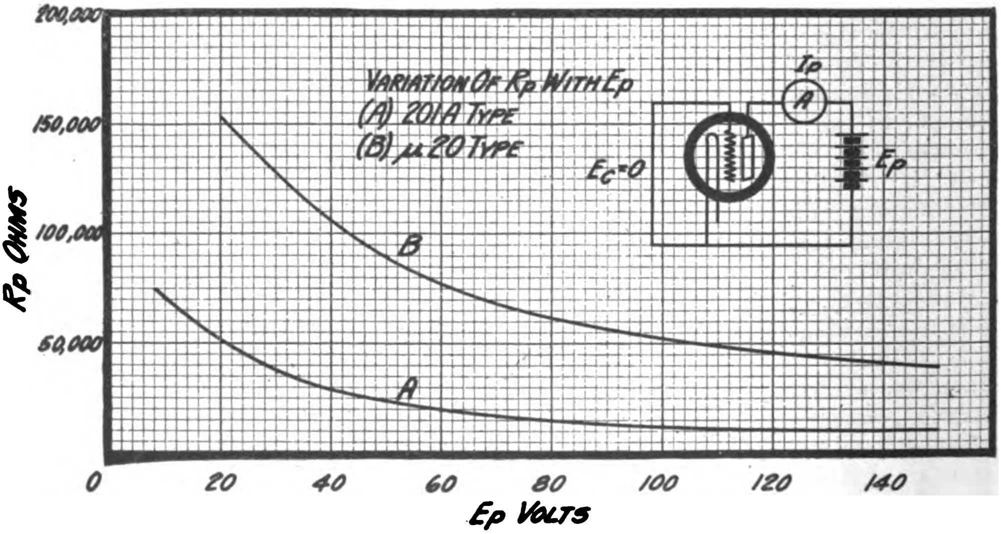
$$A = \frac{10 \times 120{,}000}{17{,}250 + 120{,}000} = 8.74 \text{ or } 87.4 \text{ percent}$$

of the mu of the tube.

It is evident that as R gets very large A approaches mu. The ***maximum*** amplification that can be obtained per stage then is mu. The rate at which A rises with increases in R is less than would at first be expected due to the fact that E_p is continually decreasing and hence R_p and r_p rising.

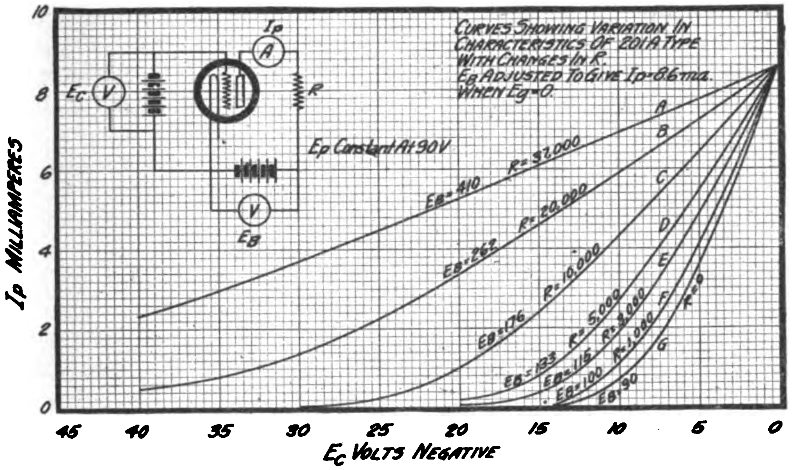
In Figure 10 a curve is given showing the percentage of mu obtained with varying ratios of R to r_p. Since the rate at which r_p will increase with increases in R varies this is the only satisfactory way to plot a general curve. The amplification in our problem could more easily have been obtained by using this curve. $\frac{R}{r_p}$ in the above case was $\frac{120{,}000}{17{,}250}$ or approximately 6.95. For this value of the ratio we find the percentage of mu obtained to be approximately 87.5 which agrees with our previous answer since 87.5 percent of 10 is 8.75.

To get a good percentage of mu per stage it is well to make R fairly high and keep r_p as low as possible by making E_p high. This can only be done by increasing E_B since there will be a greater



THE VARIATIONS IN THE FILAMENT-TO-PLATE RESISTANCE

FIGURE 5: *These curves show the way in which the filament to plate resistance varies with plate voltage. Note that although the curves do not appear to rise rapidly as the plate voltage is decreased the resistance is actually increasing rapidly since the plate resistance values on the left are high.*



THE PLATE CURRENT PLOTTED AGAINST GRID VOLTAGE

FIGURE 6: *These dynamic curves, in which plate current is plotted against grid voltage, show how a greater portion of the curve becomes linear as the plate resistance R is increased. The portion of these curves used in amplification should be linear.*

drop in R as it is increased and less of the "B" voltage will be applied to the plate. If a tube having a mu of ten is used and one combination gives a voltage amplification of 6 and another 8 the difference does not seem very great. If say three stages are used in cascade then the overall amplification of the combination becomes 216 and 512 respectively, which shows it is worth while to secure the additional amplification.

A high "B" battery voltage is necessary to secure good results with this type of amplification. In the first place where 135 volts is used in the plate circuit, calculations from the curves given will show that only 18 to 40 volts are actually applied to the plate the average being about 30 for the low mu tubes. This will be somewhat higher for the high mu tubes due to their higher plate resistance and averages about 50 volts.

This low voltage means a high value for R_p. It also means a lower mu. Although mu is fairly constant over the normal plate voltage range specified for amplification it decreases rapidly when voltages of the order of 20–25 and 30 – 35 for the low and high mu tubes respectively are used as plate potentials.

Figures 6, 7 and 8 clearly show the advantage of using high plate voltages. This increases the linear portion of the curve over which distortionless amplification can be secured. Increasing the plate voltage from 135 to 180 when using a 201-a type tube and a .12 megohm coupling resistance increases the total grid swing permissible from 10 to 16 volts. Where a stage is to handle maximum grid voltage variations the grid biasing battery should be adjusted so the normal bias operates the tube in the middle of the linear portion of the curve.

In the above case, for example, a bias of 5 and 8 volts respectively would be used permitting a peak voltage of 5 and 8 to be applied to the grid and amplified without distortion. It should be remembered that as the signal is amplified and increases in amplitude provision must be made for the greater variation in grid voltage.

An inspection of the curves in Figure 8 shows that to get much variation in E_g without producing distortion, i.e., operating where the curves begin to bend, a high plate voltage has to be used. With only 135 volts "B" battery the high mu tubes should therefore only be used on the first stage or possibly first two stages if the signal is weak.

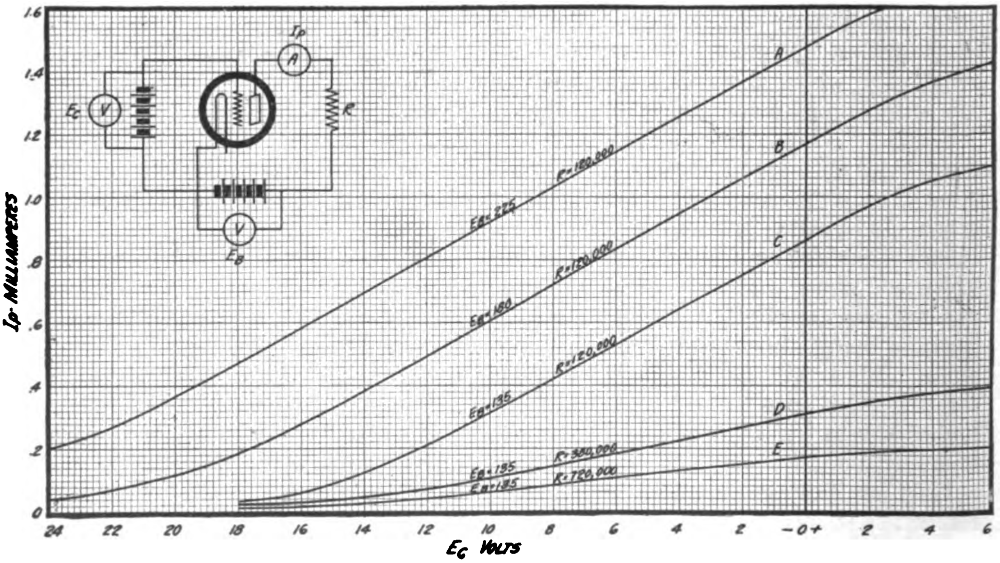
Unless the voltage is raised a 201-a type tube which will permit higher variations in E_g should be used next. Either a tube of this type or a power tube of the new type should be used in the last stage both because of the larger variation in E_g which can be used and because to get maximum power from a tube the impedance of the output circuit should be equal to that of the tube. Since the impedance of the new speakers is rather low a low value of r_p is necessary to get maximum power.

Only enough negative bias should be used to prevent the grid going positive because increasing this bias increases the plate resistance of the tube which for the reasons previously noted is objectionable.*

So far only the problems of getting a variation in drop across R which was proportional to e_g have been discussed. They have been concerned with amplification of signals of varying amplitude. This variation in potential has to be applied to the grid of the following tube. This is ordinarily done by using a "coupling" condenser which offers very little reactance to the flow of alternating currents but practically infinite reactance to the high direct current voltage from the "B" battery. This is shown at C_g in the amplifier diagram.

If the coupling resistance is non-inductive the drop across R will be almost independent of frequency. When the frequency rises to the point where the reactance of the interelectrode capacities becomes appreciable there will be a decrease in amplification with increase in frequency.

In tubes of the 199 type this capacity is low enough so no trouble from this source occurs for frequencies up to about 300 kilocycles. The effective capacity between the electrodes increases with R and may become ten or more times the geometric capacity (that due to the



THE PLATE CURRENT AND GRID VOLTAGE IN A 201-A TYPE TUBE

FIGURE 7: *These curves show the relation between plate current and grid voltage for a 201-a type tube with different "B" battery voltages (E_B) and plate resistances (R). Note that as the "B" battery voltage is increased the portion of the curves below O grid voltage which is linear is increased; this permits a signal of higher amplitude to be amplified without distortion.*

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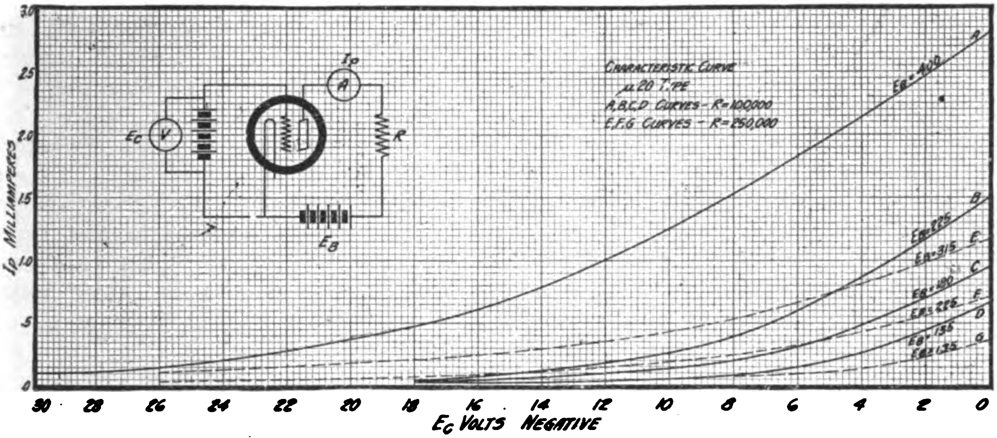
*See appendix (d).



THE RELATION BETWEEN PLATE CURRENT AND GRID VOLTAGE FOR A MU-20 TUBE

FIGURE 8: *These curves correspond to those in Figure 7 except that they are for a mu-20 tube. These show that only a very small grid variation can be permitted if distortionless amplification is to be secured. If grid variations of the order of those permissible on a 201-a type tube are to be used the "B" battery voltage will have to be about 400 as shown in curve A.*

dimensions of the elements, spacing, etc.) and therefore more serious.* In high mu tubes this capacity is large and may become objectionable at the higher audio frequencies. Considerable trouble from this source can occur in very high mu tubes having a low mutual conductance or high plate resistance.

Where a coupling condenser is used, as is generally the case, there may be marked frequency discrimination. This is frequently disregarded and the plot of amplification of such an amplifier against frequency is represented as a straight line. The reactance of this condenser is inversely proportional to the frequency.† This capacity in series with the tube input capacity, the resistance R_{g-f} and grid-leak (these three being in parallel), is in shunt to the resistance R. It is quite evident that if the leak has a low resistance, and the input circuit low resistance, such as is obtained with a positive grid, the impedance of the output circuit of the first tube will vary considerably with frequency. If the grid is kept negative R_{g-f} can be neglected. If then the leak can be kept high the capacity of the coupling condenser can be fairly low without the variation in its reactance over the range of say 60 to 3,000 cycles causing much frequency discrimination. The voltage across R, divides itself between C and R_g. The drop in C is proportional to its reactance.*

If, as is generally the case, the grid is operated with no bias there is a resultant accumulation of electrons on the grid, due to the occurrence of a rectifying action (see Figure 2) which is similar to that in a detector tube having a grid condenser. This must be removed to minimize distortion. A time constant of discharge enters here.† This is one of the reasons a lower resistance leak is commonly used in the last stages of an amplifier of this type. The grid becomes more positive and more charge accumulates which has to be removed to minimize distortion. This lower resistance leak, however, introduces the distortion previously mentioned.

If only a .006 coupling condenser is used and a .1 meg leak, the variation in amplification over the audio range *may*

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*See figure 16 in R. B. King's "Thermonic Vacuum Tubes and Their Applications."—*Bell Tech. Journal*, Oct., 1923.

†See appendix (f).

*See appendix (f).

†See appendix (g).

be as high as 75 percent depending on r_p. To minimize this a coupling condenser of at least .1 microfarad should be used. A .5 microfarad condenser is somewhat better although increases in capacity after this do not give a corresponding lessening of frequency discrimination.*

Where the input to the first stage is connected to the output of a regenerative detector a .001 or .002 mfd. condenser is frequently connected across R to offer a low impedance path to the radio frequencies. An inspection of the circuit used will show that this is across r_p. The variation of reactance of this condenser to audio-frequencies may be enough to cause very marked frequency discrimination with consequent distortion. This condenser should be as *small* as possible to secure oscillations. If this has to be fairly high it is better to use a transformer in the first stage. The circuit comprising the primary of the transformer and this condenser can still offer inductive reactance to the low frequencies.

Reviewing briefly then what has been found note that the grid should never go positive in a high mu tube and only very slightly so, if at all, in low mu tubes. The value of R, the coupling resistance should be several times that of r_p, the alternating current plate resistance, to secure a reasonable proportion of the voltage amplification of the tube and to increase the linear portion of the dynamic curve. This in turn means a high value of E_B to keep E_p fairly high and r_p low. Since, except in the last tube, we are interested in voltage amplification high mu tubes should be used if possible. It must be remembered that the linear portion of a high mu tube is proportionally less than that for a low mu tube and if it is to be used after the first stage a high plate voltage must be used to increase this linear portion. If this cannot be done a lower mu tube should be used. The coupling condenser should be large and the leak have a high resistance so the variation in the reactance of the coupling condenser at audio frequencies is only a small proportion of the resistance of the leak. To keep r_p as low as possible (i.e., the effective plate voltage as high as possible) the negative bias should not be higher than necessary to prevent the grid going positive in successive stages. It should, therefore, be increased in the last stages.

An inspection of the curves given will show that there is considerable latitude in the choice of constants for an amplifier depending on the tubes, "B" battery voltage, etc.

The foregoing material has been presented in the hope that enough of the fundamental principles involved have been given to permit the designing of an amplifier for a specific need.

Appendix

(a) The capital letters E, I and R are used to denote respectively direct-current voltage, current and resistance. For convenience the small letters e, i and r are used to denote respectively the alternating current voltage, current and resistance. The subscripts g, f and p denote respectively grid, filament and plate. Rp for example denotes the direct current plate resistance and e_g the alternating voltage on the grid. X is used to denote reactance with the subscripts c and L to indicate capacitative and inductive reactance. The subscripts B and C indicate the usual "B" and "C" battery circuits and are used for example to distinguish between the voltage of the "B" battery and that actually applied to the plate. E_B indicates the "B" battery voltage and Ep the voltage actually applied to the plate, the two being equal only when there is no resistance in the output circuit. In Figure 1 $C_{g\text{-}p}$ indicates the capacity from grid to plate, and so on.

(b) Mu is the ratio of the plate to grid voltage variations which produce the same changes in plate current.

(c) Van Der Bijl's formula in his "Thermionic Vacuum Tubes" which holds to a first approximation is $Ip = \left(\frac{Ep}{\mu} + Eg + c\right)^2$

(d) The effective voltage on the plate is of course a function of the grid voltage. For grid biases below O the effective voltage is $E_p - \mu E_g$. To compute the plate resistance from Figure 5 for values of E_g other than O use this relationship to secure the effective value of E_p. If the

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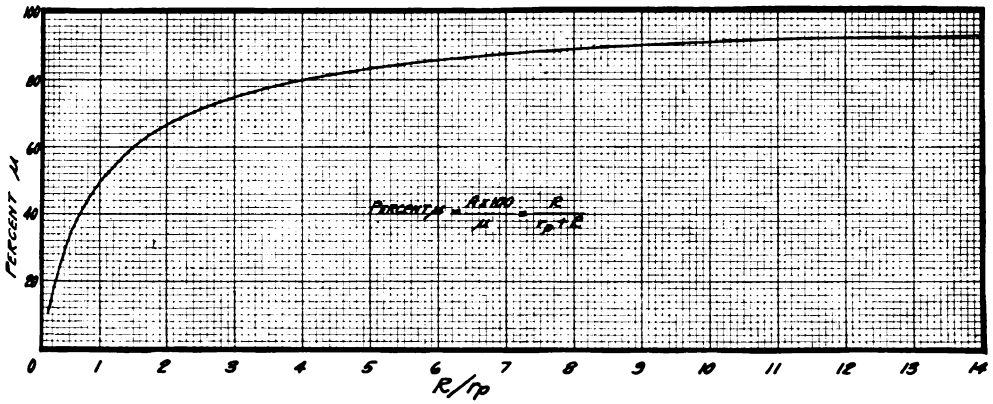
*See appendix (h).



A CURVE THAT SHOWS THE PERCENT MU AMPLIFICATION PER STAGE

FIGURE 10: *This curve shows the percent mu (of the tube) amplification which can be obtained per stage as the ratio of the coupling resistance to the plate resistance is varied. This shows both that mu is the maximum amplification which can be obtained per stage and that the amplification obtained approaches this value as the ratio of the coupling to plate resistance becomes very high. It also shows that the plate resistance should be kept low by keeping the plate voltage high.*

bias is—2 for example and E_p is found to be 30, the mu of the tube 10, then the effective value of E_p is 30 — 10 x 2 or 10 volts. Reference to Figure 5, then, will give R_p.

(e) The amplification per stage is the ratio of the output voltage to input voltage considering all of the output voltage to be impressed on the second grid. By definition (see (b) above) $\mu E_g = E_p$. That is a variation in the grid voltage of E_g will produce mu times this variation in E_p. Therefore i_p the alternating current component of the plate circuit in which we are interested is expressed by

$$i_p = \frac{\mu \, Eg}{r_p + R} \tag{4}$$

For simplicity this can be understood best by referring to (1). Equation (4) is comparable to (1) except that alternating voltages and resistances are taken into consideration. In our case we have used non-inductive resistances so that their alternating current resistance is substantially the same as the direct current resistance and this value of R can be substituted directly. However, r_p is not equal to R_p as was pointed out above but is approximately half R_p. To get r_p divide R_p derived from Figure 5 by 2. Eg' is then the product of i_p and R or

$$Eg' = i_p R = \frac{\mu \, EgR}{r_p + R} \tag{5}$$

the total amplification is the ratio of (5) and (E_g) or

$$A = \frac{Eg'}{Eg} = \frac{\mu \, R}{r_p + R} \tag{6}$$

This shows that r_p must remain constant over the portion of the curve the tube is operated on. For the portion of this curve that is linear r_p is constant as computations will show. The alternating current plate resistance r_p is the slope of the effective plate voltage-plate current curve. This slope is 2 in the average tube and approaches the theoretical value 1.5 when the effective voltage is large in comparison with the potential drop in the filament. An inspection of Figure 8 will show that the slope is roughly 2. The curves in Figure 7 give a value of approximately 1.1. The average low mu stage gives a value of about 1.25.

(f) The reactance of a condenser X_c is expressed by

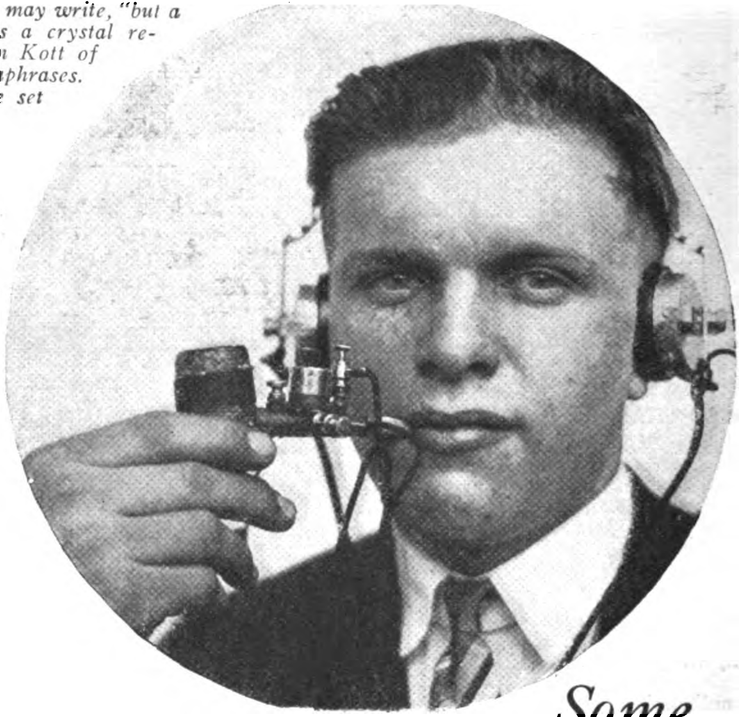
$$X_c = \frac{1}{2 \pi f C}$$

where f is the frequency, C the capacity in farads, π = 3.1416 and X_c is measured in ohms. The drop in voltage across this condenser is proportional to its reactance. This portion of the voltage across R is lost, only the drop across the leak being available for the second grid. If the leak is made large, say, .5 to 1 megohm, then the difference in reactance of a .1 microfarad condenser to frequencies of from 60 to 3,000 cycles will only be a relatively small proportion of the whole, A .5 microfarad coupling condenser is satisfactory for the average amplifier.

(g) See chapter on detection in "Principles of Radio Communication" by J. H. Morecroft.

(h) If a more perfect amplifier is wanted, one that will give amplification below 60 cycles, or one which will amplify direct current variations, a more nearly aperiodic amplifier can be made by eliminating the coupling resistance. In this case a "C" battery having a voltage equal to E_p plus E_c' should be connected where the coupling condenser normally goes (Ec' being the bias wanted on the second grid). This then "counteracts" the plate potential of the previous tube and gives a resultant negative value in addition. This will be aperiodic up to frequencies for which the reactance of the interelectrode capacities is appreciable.

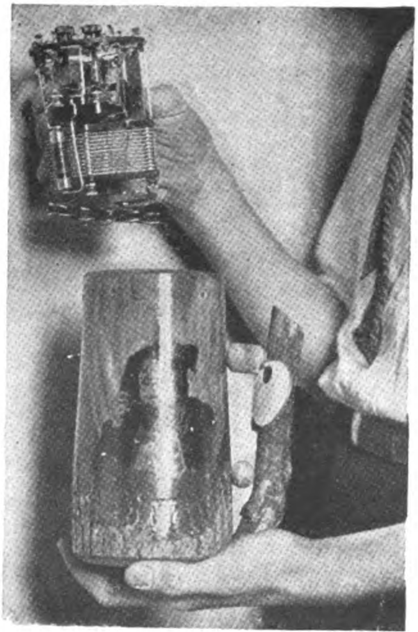
"A woman is only a woman" the poet Kipling may write, "but a good pipe is a crystal receiver," John Kott of Chicago paraphrases. He built the set for $1.50.



Underwood & Underwood

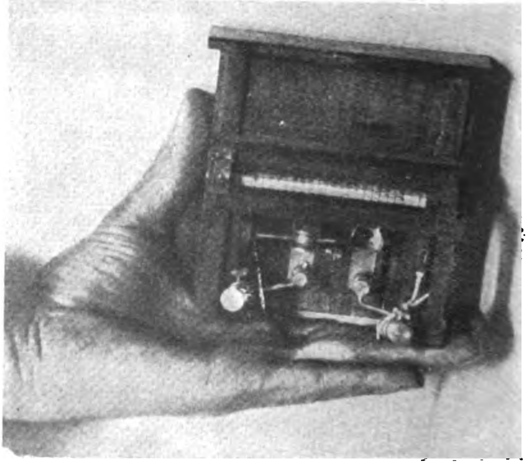
Some STUNT SETS

Peculiar but Practical Receivers Built by Radio Fans



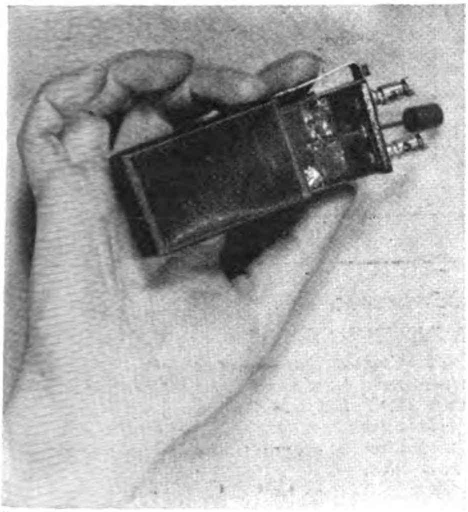
Kadel & Herbert

R. G. Fehrenz of Brooklyn can listen in on a prohibition lecture that issues from a set built in a beer-mug—if he wants to.



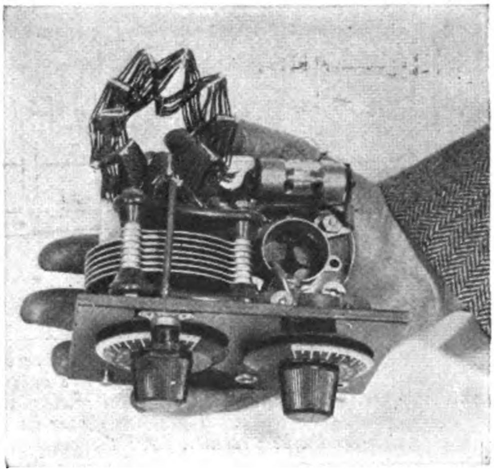
Kadel & Herbert

This miniature set, built in a toy piano by C. W. G. Brown, may play the famous "Prelude" of Rachmaninoff—if the famous "Prelude" of Rachmaninoff is being broadcast from a studio.



Kadel & Herbert

This miniature radio set was built in and about an ordinary matchbox by Edward Bessinger of Elmhurst, N. Y. The crystal detector has been placed inside while the set is tuned by sliding the cover on and off.

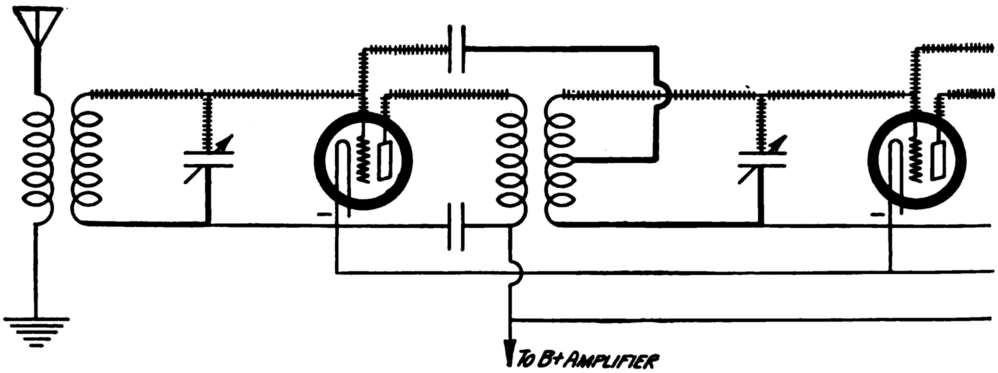


Kadel & Herbert

This one-tube set built by F. G. Mathews of North Bergen, N. J., in which a simple regenerative circuit is used, scarcely covers the whole of a man's hand. Although the set has been compactly built there is little crowding of the instruments.

Pacific & Atlantic

To while away her spare moments while waiting to keep appointments, Miss Addie Rolf of New York need merely to open her leather card case and listen in on what the wild ether waves are saying. But who would keep Miss Rolf waiting?



CRITICAL WIRES IN A RECEIVING SET

FIGURE 1: *When you connect up your receiver, it is essential that some parts of the wiring be as short as possible and that they be kept separated from other wires. In the neutrodyne circuit (as shown above) the most critical wires are those shown in the wiring with small rungs crossing them. The wires shown in heavy black lines are less critical but should be spaced for the best results. All the other wires shown in the diagram may be bunched together and run in a cable.*

Important Kinks in Wiring

What wires to "bunch," what wires to isolate and when to use spaghetti covering.

By LOUIS W. HATRY

IN general "wiring" can be done in two ways and with two kinds of materials. First, there is bus-bar wiring which is square-rigged, a thing of geometrical beauty and nicety. And there is the popular "straight-line wiring." The point of the latter is that it does not choose square corners or parallels; it eliminates care and accuracy.

Both kinds of wiring can be done with stiff or flexible wire.

The bus-wiring looks best if square or round bus-wire is used, covered (or not) with spaghetti.

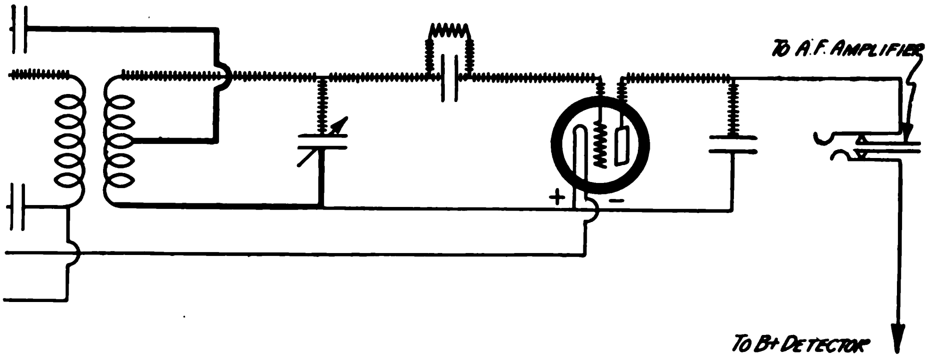
The straight-line wiring, which is the simplest, may be done either with stiff or flexible wire, but the flexible wire is easiest to handle so it therefore fits in with the nature of the straight-line job.

It is but natural that the bus-wiring is generally preferred. It is a beautiful way to connect up, if it is done properly. Done improperly it will make a maze that is fairly dizzying. To avoid the maze requires a little thought in looking for short-cuts that require a minimum of bends.

Don't let the difference between square and round bus-wire bother you insofar as losses are concerned. Choose one or the other only by your preference in appearance. The writer, for instance, likes best and almost consistently uses square bus-wire. But he has met many people who like round bus-wire for no other reason than its appearance.

For the same reason, use—or don't use—spaghetti. In the audio-frequency circuits spaghetti cannot matter. In the radio-frequency circuits it will not make much difference if you take the necessary precautions of spacing the wires properly. Its loss can only be a dielectric one.

The size of the bus-wire should not bother you. In self-supporting wiring, the wire must be of sufficient size and of the proper material to have the required stiffness, rigidity, for self-support.



In straight-line wiring the wire may be relatively small.

There are rather radical differences in the necessary methods of wiring of the radio-frequency circuits of a receiving set and the audio-frequency and direct current circuits. The two divisions of radio-frequency and audio-frequency are sufficient for discussion here.

A five-tube circuit, with two stages of tuned and neutralized radio-frequency amplification, with a vacuum tube detector and two stages of audio-frequency amplification will be taken as an example.

In Figure 1 are shown the radio-frequency circuits of the set mentioned. Some of the connections are crossed with little rungs, some are left plain and still others heavily lined. Differentiation was necessary, the reason for which will later become apparent.

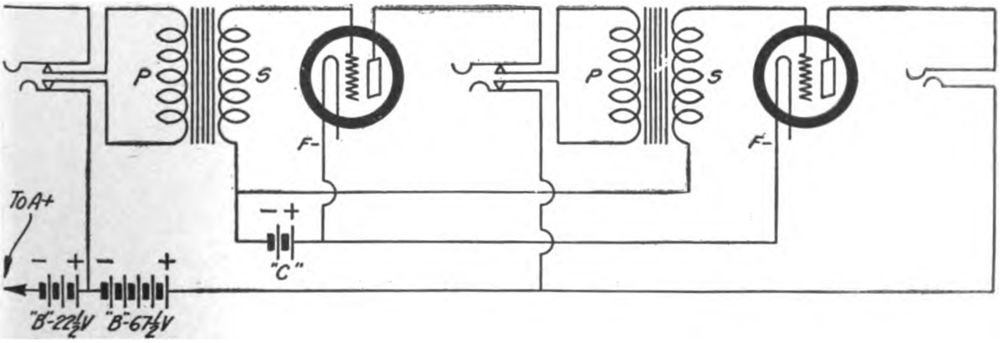
The coils, it must be mentioned, should be mounted in a clear space with no wires run through them or near them if such can be avoided. If a wire must come near, do not let it come nearer than one-half inch.

As most of us choose bus-wiring because of appearance and in spite of added capacity, respect for the capacity it does add should make us take the necessary precautions to see that the capacity is kept low.

The condenser, in turn, must be mounted away from the coil for two reasons; first, to keep the capacity relation low and, second, to keep eddy-current losses down.

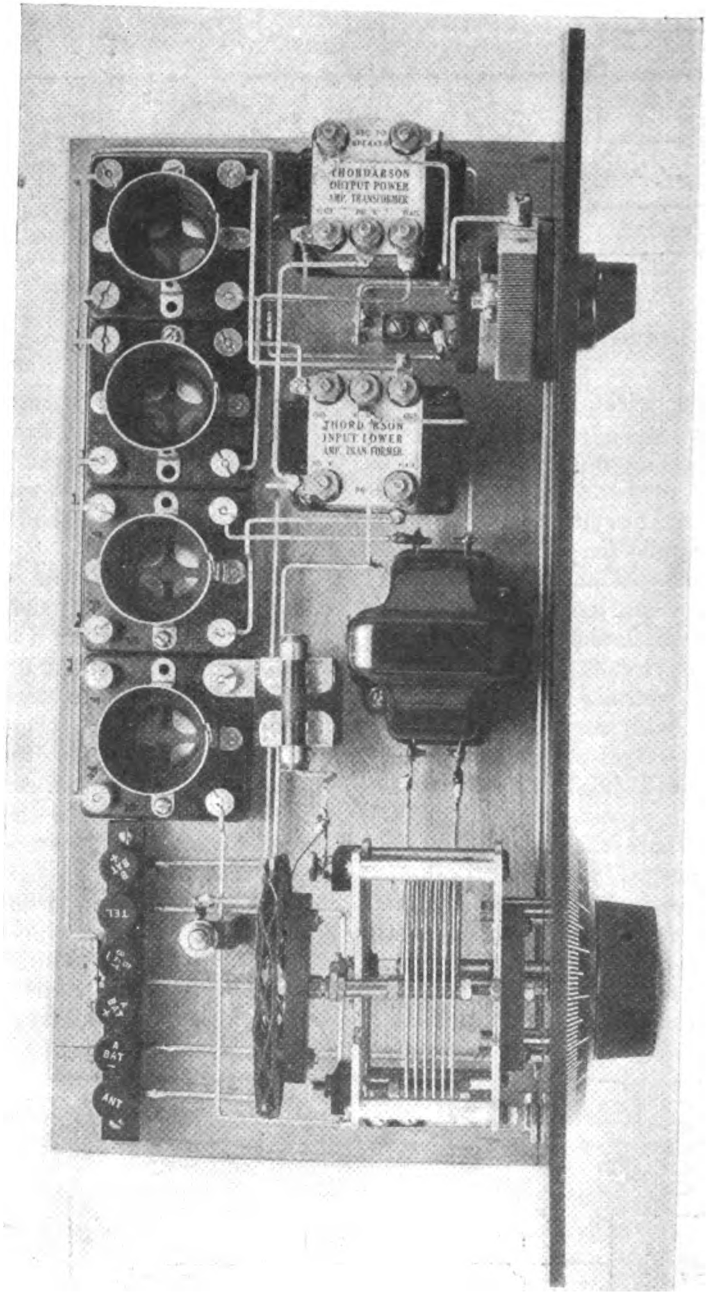
Both effects are important.

Those leads that are at highest radio-frequency potential difference to the grounded parts of the circuit are marked by the tiny rungs. These leads should



HOW TO WIRE A TWO-STAGE AUDIO-FREQUENCY AMPLIFIER

Figure 2: *The author tells in this article some of the precautions that should be taken in wiring up an amplifier such as this. One of the important points is to bunch the filament circuits and "B" battery wires.*

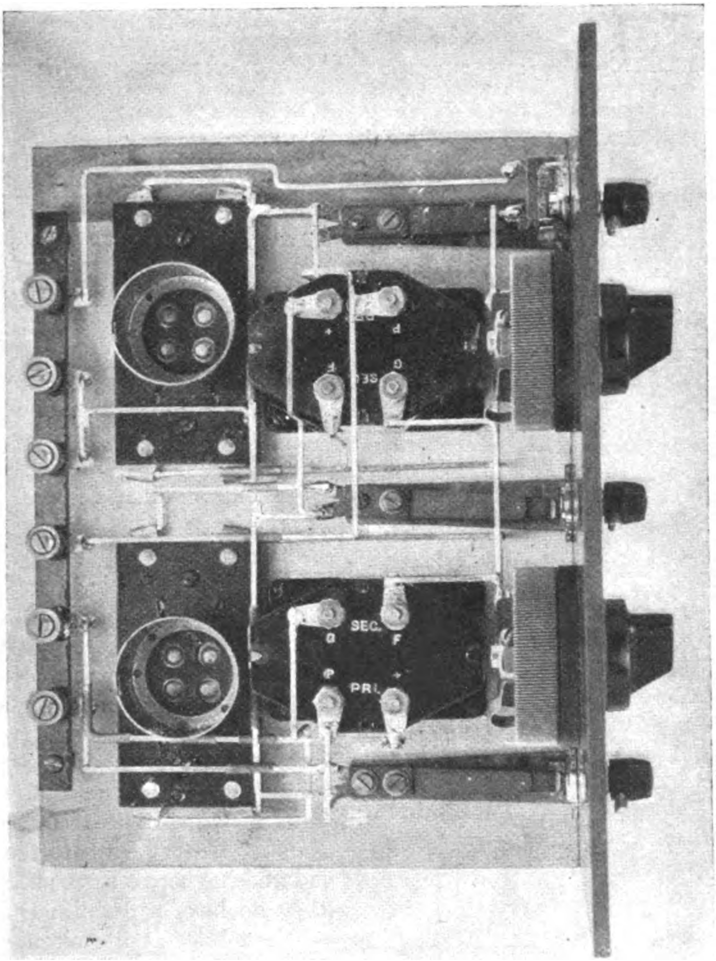

THORDARSON OUTPUT POWER AMP. TRANSFORMER
THORDARSON INPUT POWER AMP. TRANSFORMER
TEL
A BAT
ANT

A NEATLY WIRED RECEIVER

FIGURE 3: *Notice that the regular square bus-bar type of wiring is used and notice how neat are the right angle turns.*

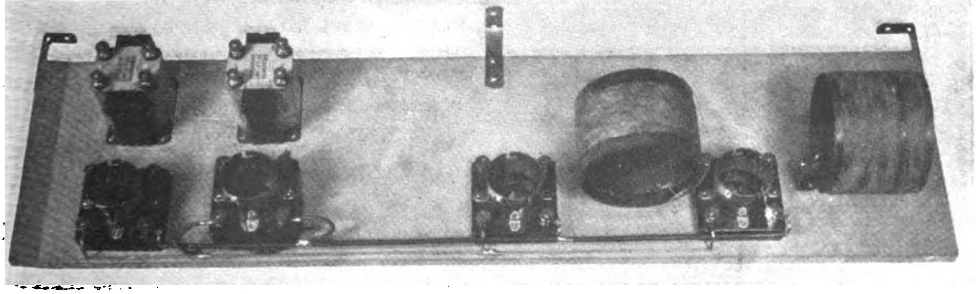
be short. They should cross others at as nearly right-angles as possible. These leads should be well separated from any leads that they parallel.

The leads of next importance are the heavy lines of Figure 1. In general these leads carry radio-frequency current or are at some radio-frequency potential



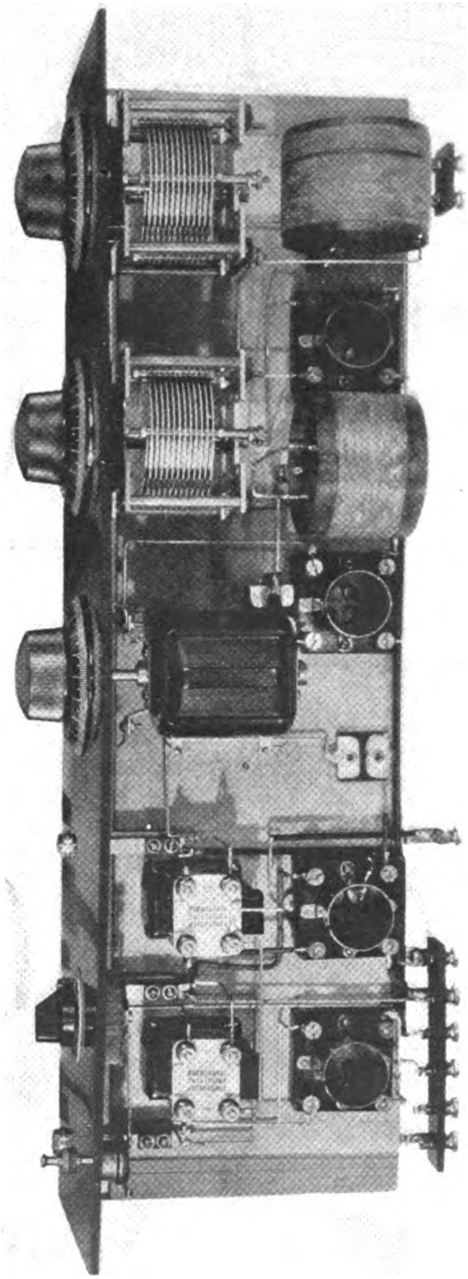
A TWO STAGE AMPLIFIER

FIGURE 4: *This picture shows how the diagram in Figure 2 was used for wiring up the two stages of transformer-coupled amplification.*



A SKELETON OF A TUNED-RADIO-FREQUENCY SET

FIGURE 5: *Notice that the wiring of the filament circuits of all the tubes is run together in a bunch. This is what the author refers to when he speaks of "bunch-wiring."*



AN EXAMPLE OF GOOD WIRING

FIGURE 6: *This picture illustrates the layout and wiring for one stage of tuned-radio-frequency amplification with regenerative detector and two stages of transformer-coupled audio amplification. The wiring is done with square bus wire, and spaghetti is used only where absolutely necessary to prevent short circuits.*

Another Hoffman Chart

IN POPULAR RADIO *for next month—March—will appear No. 14 of the series of computation charts designed for the practical guidance of the experimenter who designs and builds his own sets. This chart will give a simple and accurate method of calculating the inductance of toroid coils.*

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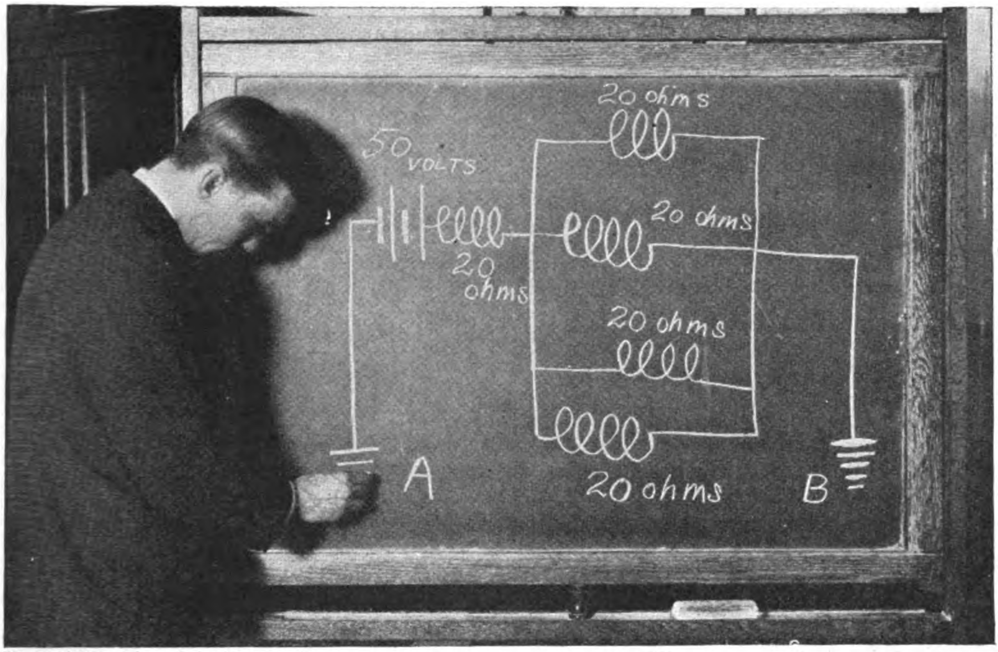
above the grounded parts of the circuit. They should also be as short as possible, and they should be well separated. Such leads should be separated by a distance of about an inch when run parallel.

The leads of which the length is least important and of which the relation to each other is entirely unimportant, are marked in light black. This is because they are at ground radio-frequency potential—zero. They are of a definite potential, however, in relation to the "runged" connections. It is sometimes convenient to run these "ground wires" all together. In the analysis of the circuit from a radio-frequency standpoint the "B" battery leads to the coils are considered to be at zero potential although they do have a definite DC potential.

Next look at the circuits in Figure 2. These are the audio-frequency circuits of a five-tube set. Every lead shown carries current vibrating at audible frequencies or rather some audio-frequency potential with respect to other parts of the circuit.

As installed in the average radio receiving set the leads to the audio-frequency circuits are usually kept short. Very short leads in an audio-frequency amplifier are not nearly as important as in the radio-frequency currents.

Spaghetti on the wiring adds no losses in an audio-amplifier. The filament or DC wiring should generally be run along the sockets close to the baseboard. This will leave more room for the remainder of the wiring. Leads can be taken off to the rheostats and filament terminals.



From a photograph made for POPULAR RADIO

HOW WATTAGE IS FIGURED WHEN RESISTANCE AND VOLTAGE ARE KNOWN

The effective resistance of the four resistances that are connected in parallel is 5 ohms which is obtained by adding their reciprocals or 1/20 which will equal 4/20 and then dividing this answer into one. The quotient is 5 ohms. This 5 ohms is added to the 20 ohms at the left with which the four parallel resistances are in series. The total effective resistance of this circuit is then 25 ohms. The text explains the rest of the problem.

HOW A CRYSTAL RADIO RECEIVER WORKS

Chalk Talks in Radio—No. 4

This is the fourth article of the series. The preceding articles were "Ohm's Law in a Nutshell," "Watt's Law in a Nutshell" and "What Current Means in Radio." Keep these articles for reference

By J. W. GOOSTREE

THE answer to the problem in the last chalk talk is as follows:

50 volts divided by 25 ohms equals 2 amperes.

2 amperes times 50 volts equals 100 watts.

100 watts then is the power that was represented in the electrical circuit that contained a number of resistances.

In this talk we will confine our conversations to radio proper.

We will put a simple radio receiving set on the table, and pull it apart.

First, we'll lop off the antenna and put it in the upper left-hand corner of Figure 1. This symbol looks like the letters "T" and "V" placed upon one another.

The antenna is that part of a receiving

set that reaches out into the ether, gathers in the high-frequency current and leads it down through the entrance switch, through the primary of the loose coupler, and into the ground.

The symbol for electrical "ground" or "earth" is a vertical line with a few short horizontal lines underneath it. This is shown to the left at the bottom of Figure 1.

We spoke of loose couplers and high-frequency current, a moment ago. In the coupler the current leaves the primary which is at P in Figure 1, and passes into the secondary winding at S. How does this happen?

It is like this:

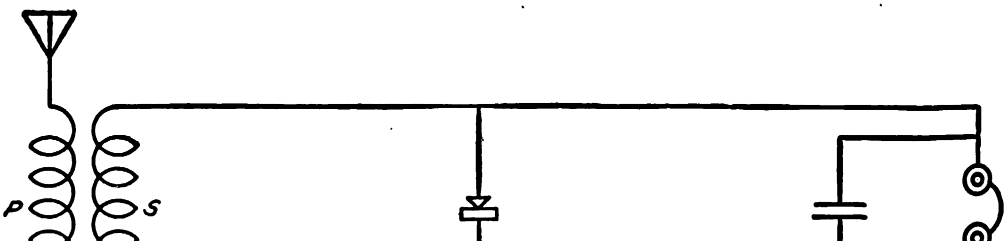
When some broadcasting station is sending those high-frequency waves that fly around everywhere at the speed of light until some of them run into one of the thousands of antennas that are almost as conspicuous today as telephone lines, they induce in the antenna the electric impulses that flow down the lead-in wire. They come to the primary of the loose coupler, and rush through its windings. This causes a sympathetic electric wave motion through the secondary circuit, but in this case the impulses are caught like rats in a trap. Then, here they go along the winding, and over the other wires toward the detector.

When they start through the crystal detector, it becomes "peeved," and throws a "caloric fit." The detector in its refusal to allow these impulses to flow through in one direction, totally forgets about the impulses from the opposite direction, and they slip past the unsuspecting crystal. One-half of these impulses then dashes into the condenser, like fiddler crabs into the sand.

And blam! before they discover they can't get through the dielectric, the microfarads kick them out, heels over head.

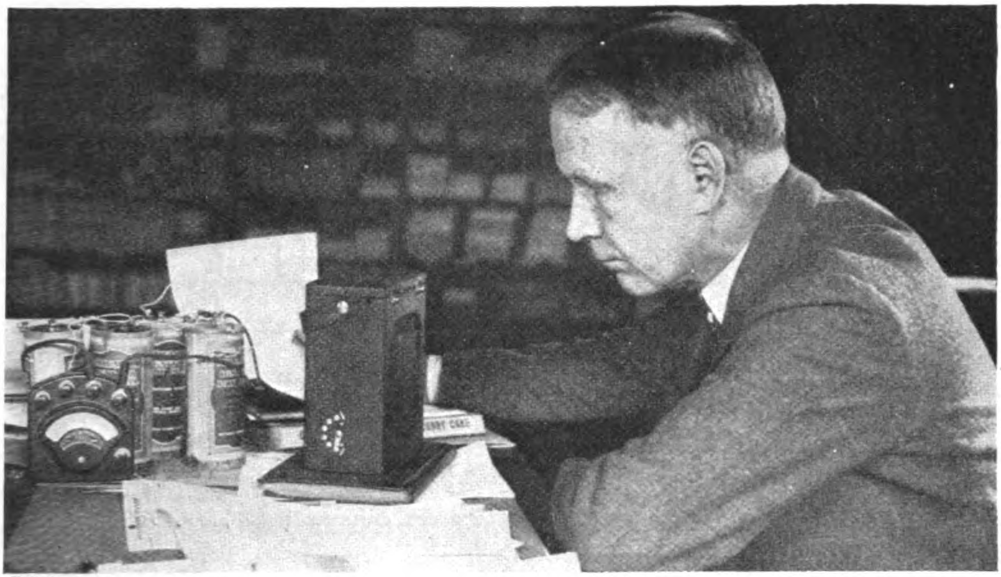
So, into the windings of the receiver they go, pellmell, and mad as hornets because the microfarads kicked them out of the condenser. They hit the ohms in the receiver coils like Yale's eleven hitting Harvard's defense line in a football championship game.

The ohms do their best to stop the milliamperes' mad onslaught, but they find it impossible. The milliamperes overcome the ohms' resistance and on they go through the very heart of the telephone coils. This turmoil going on all around the cores of the coils makes them nervous and shaky. This attracts the attention of the telephone receiver's diaphragm and it vibrates in sympathy with the cores, but in so doing never shirks its own duty, which is the changing of the electric impulses into sound waves. That is the drama that goes on inside a simple radio circuit.



A SIMPLE RADIO RECEIVING CIRCUIT

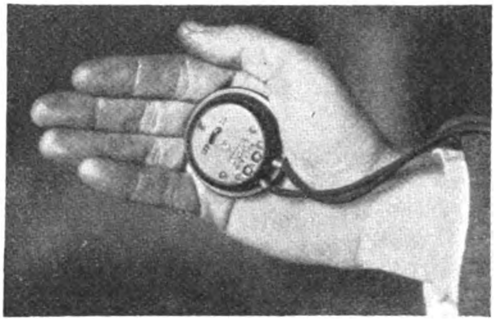
FIGURE 1: *P represents the primary of the loose coupler and S the secondary. The symbol in the center is used to represent a crystal detector; the short parallel lines at the right designate a fixed condenser; and the two coils at the extreme right are symbols for headphones.*



United

HOW THE APPARATUS
LOOKS IN USE

The rectangular leather-covered box shown on the desk above contains the microphone that picks up the sound vibrations of the voice and converts them into electrical energy. Current is drawn from the four dry cell batteries. The picture on the right shows how the receiver is held close to the sensitive skin of the palm of the hand so that the vibrations may be easily heard. Professor Robert H. Gault, the inventor, is shown experimenting with the apparatus.



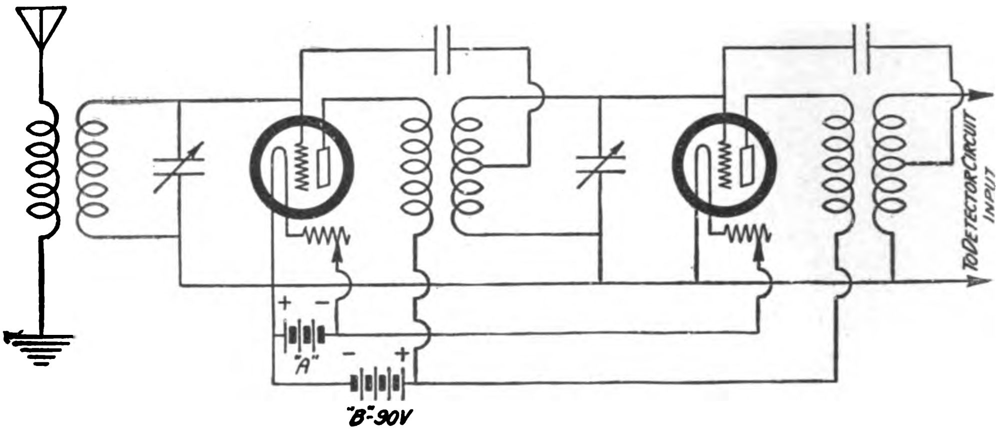
Helping the Deaf to Hear Through Their Hands

TO restore the ability to "hear" to those who are deaf, a specially constructed telephone that purposes to provide new ears for them in the palms of their hands has been developed by Professor Robert H. Gault of Northwestern University.

The basis of his device is to convey vibrations of sound by mechanical means to a sensitive skin area, where they may be felt and translated back into words.

The apparatus, (as is shown by the illustration reproduced on this page), is simple. A microphone operated by dry cell batteries picks up the sound of the voice and transmits it to a telephone receiver which is placed in the palm of the hand. The vibrations are then carried to the sensitive surface of the skin through the diaphragm of the receiver.

Previous experiments along this line have shown that persons who are totally deaf may "hear" and enjoy musical vibrations such as those obtained by placing the fingertips upon the sounding-board of a piano; but this is thought to be the first time that the sense of touch has been used to interpret the vibrations of speech.



A WASTEFUL METHOD FOR CONNECTING GRID RETURNS

FIGURE 1: *This diagram shows a poor method, from an efficiency standpoint, of connecting the grid returns of a radio-frequency amplifier. Notice that they are connected to the positive filament terminal which produces a large drain on the "B" batteries.*

How to Cut Down Your "B" Battery Bill

Do your "B" batteries run down quickly? If they do—read this article. It tells how to reduce the drain on your "B" batteries and at the same time get better reception.

By EDGAR H. FELIX

ECONOMY of operation is rarely viewed with the same importance as selectivity, sensitiveness and volume when a new radio receiving circuit is decided upon. Yet, by the observance of a few simple precautions, it is possible to cut the "B" battery bill almost in half, without sacrifice of any of the other desirable qualities of the ideal receiving set.

Before analyzing several of the most widely used circuits, it is desirable to understand why "B" battery current in a receiving circuit may be reduced, without loss of volume or sensitiveness. Then the reason for the slight circuit changes suggested will be at once clearly apparent.

The useful output of any vacuum-tube circuit are radio-frequency or audio-frequency *variations* in the "B" battery current. A vacuum-tube amplifier should increase the relative intensity or amplitude of these variations, whether of audio or radio frequencies, without affecting their frequency.

The output of the "B" battery is, in effect, a direct-current carrier, passing through the plate circuit of a vacuum tube. As small voltage variations are impressed upon the grid, the plate current, drawn from the "B" battery through the meshes of the grid, is caused to vary but to a much greater degree than the impulse supplied to the grid. Hence we have an amplified reproduction of the current in the grid circuit impressed upon the direct current passing from the "B" battery through the tube.

The amount of "B" battery current, therefore, need not be larger than is necessary to accommodate these variations.

An analogy may make this clear:

Suppose you were attempting to communicate signals by means of waves in a trough. By splashing the surface of the water with a paddle at one end of the trough, it would convey, by means of the ripple making its way to the other end, a visual signal. The amplitude or height of the ripple might be but half an inch. As long as the water were at least half an inch deep, you could communicate half-inch ripples to the other end. There would be no improvement in this primitive communication system if the depth of the water were increased to two or six feet.

The water, in this analogy, represents the plate current; the paddle, the grid; and the ripples, the fluctuations or useful output of the tube.

Wastefulness of "B" battery current is the result of passing six milliamperes through a vacuum tube for the purpose of accommodating fluctuations corresponding only to a half a milliampere.

There are three simple methods of reducing plate current:

First, by maintaining the correct potential relationship between grid and filament through the use of a "C" battery or by utilization of the negative drop across the rheostat in the negative filament lead;

Second, by employing the lowest-plate voltage which gives good results;

Third, by regulation of the filament current to the minimum which maintains good quality of reproduction.

The elements of any multi-tube radio receiver may be generally classified into three general parts:

(1) Those handling radio-frequency currents;

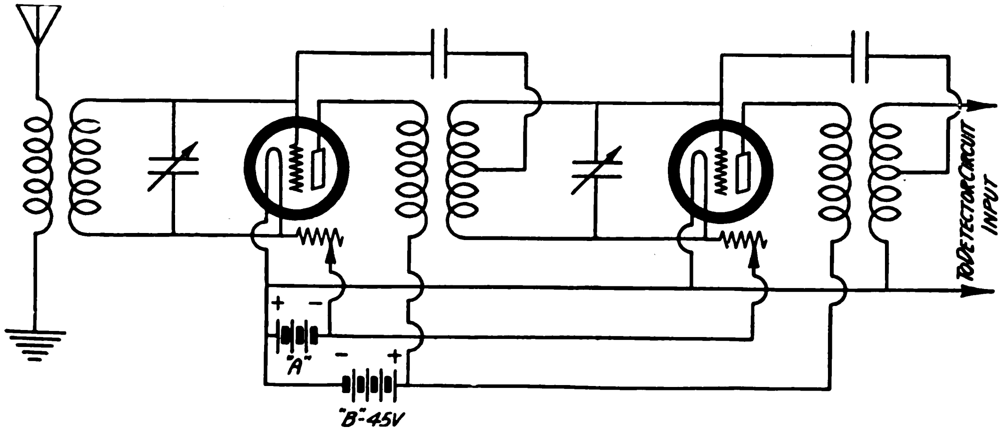
(2) Those concerned with rectification;

(3) Those devoted to amplification of audio-frequency currents.

Economy measures of a different nature are applicable to each of these general elements of radio receivers.

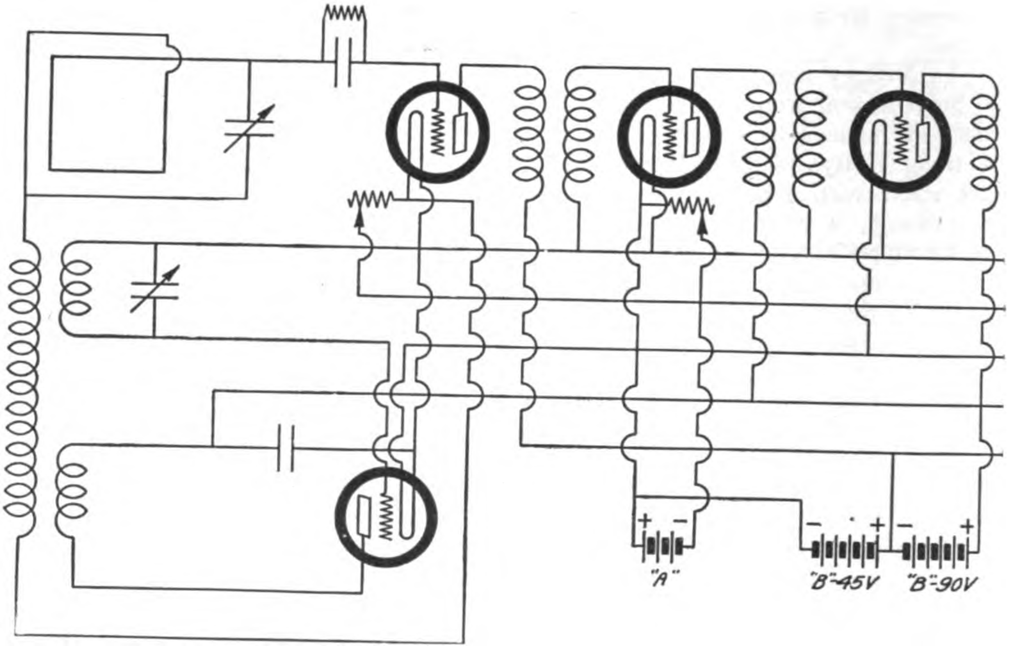
In reflex circuits these functions are combined in whole or in part and consequently the same economy measures, which can be applied to receivers having these circuit elements separated, cannot be incorporated in most reflex circuits. Reflex circuits depend for their economy on the fact that fewer tubes are required to do the same work rather than on individual economy per tube.

Negative biasing cannot always be applied successfully to the radio-frequency



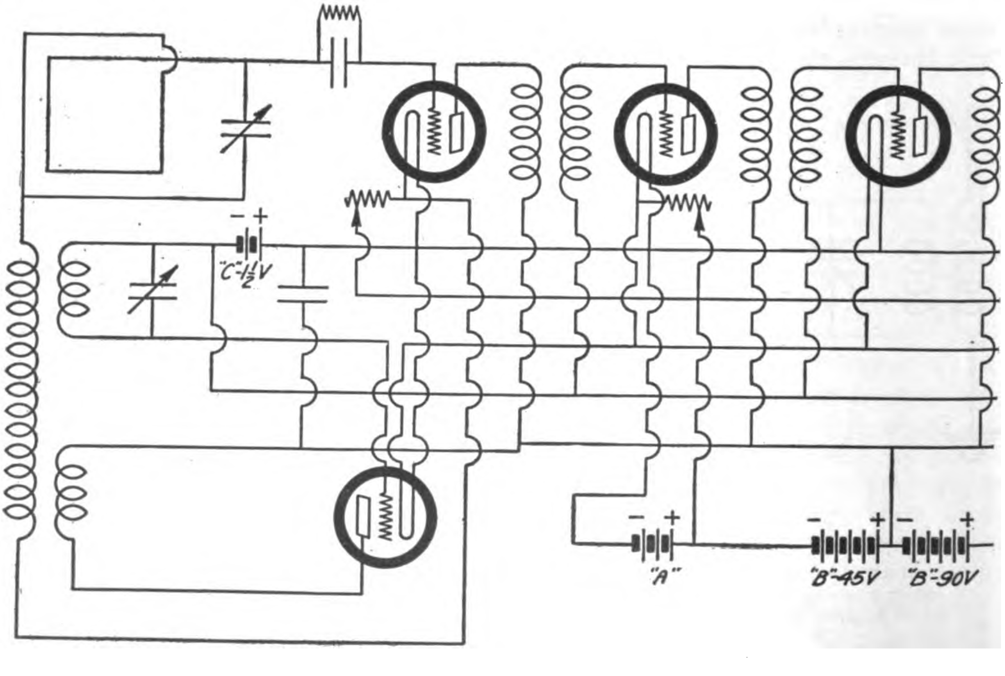
THE CORRECT GRID RETURN SCHEME

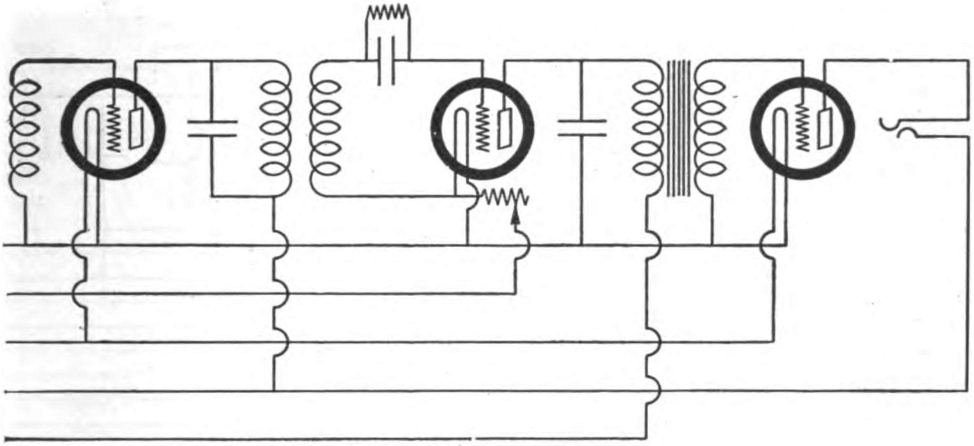
FIGURE 2: *This diagram shows you how to change the grid connections from a positive return to a negative return. Notice that in both cases the grid return wires are connected to a point between the rheostats and the filament terminal, thus reducing the drain on the "B" battery considerably by making the grids more negative.*



A SUPERHETERODYNE THAT CONSISTS OF TWO DETECTORS, THREE INTERMEDIATE-FREQUENCY RADIO AMPLIFIERS, AN OSCILLATOR AND ONE STAGE OF AUDIO AMPLIFICATION

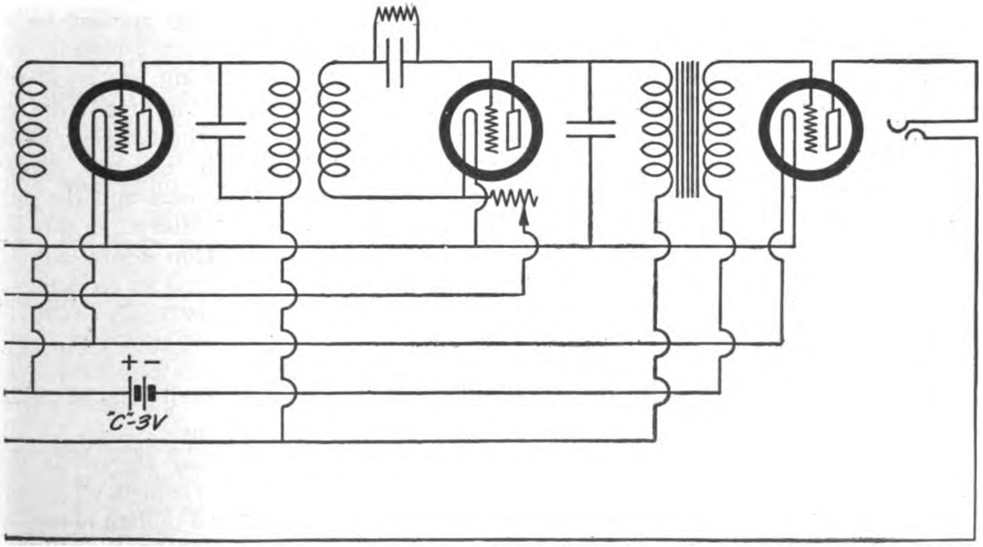
Figure 3 (Above): *This circuit is exceedingly wasteful of "B" batteries and would cause them to run down in a month or so. See Figure 4 for the information that would cut down the drain on the batteries.*

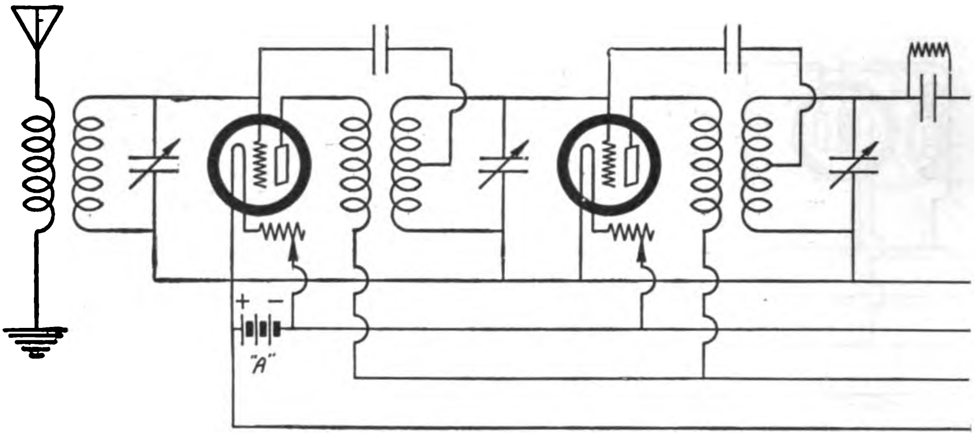




THE CORRECT HOOK-UP

Figure 4 (Below): *This diagram is a revised edition of that shown in Figure 3. Notice that two "C" batteries are incorporated—one in the grid circuit of the oscillator and one in the grid circuit of the audio amplifier. Notice that the three radio-frequency amplifiers also have their grid returns connected to the 1½-volt "C" battery. This cuts the drain on the total circuit approximately in half when considered from a "B" battery standpoint.*





THE CONNECTIONS FOR THE NEUTRODYNE WITHOUT "C" BATTERIES AND WITH POSITIVE GRID RETURNS

FIGURE 5: *This is a wasteful procedure and causes the "B" batteries to run down too quickly. The proper "over-all" connections are shown in Figure 6.*

amplifier operating on broadcast frequencies because, in unstable circuits, it will make the amplifier oscillate. The principal economy measure which can be taken advantage of in the radio-frequency amplifier is the use of comparatively low plate voltage.

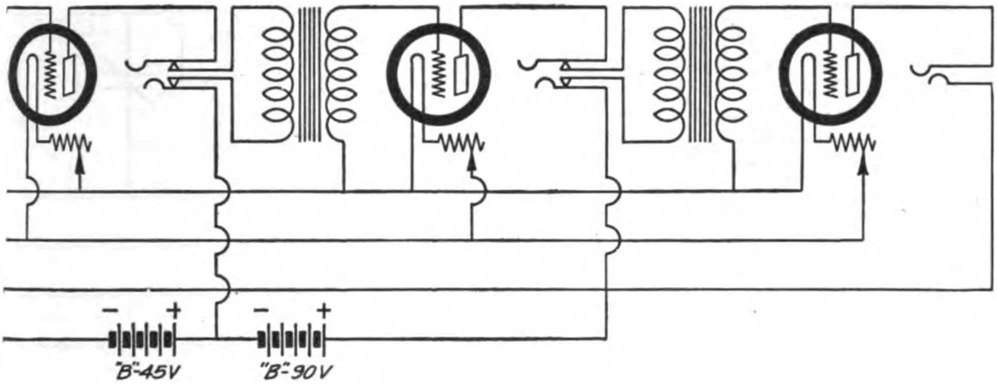
Many receiving sets are equipped with a single, high-voltage binding post supplying the plate circuits of both radio and audio-frequency amplifier tubes. While high voltage is desirable to secure the utmost audio-frequency amplification of good quality, it is not essential to effective radio-frequency amplification. Consequently, separate plate-potential binding posts for radio and audio-frequency amplifier tubes permit the use of 45 volts on the radio-frequency tubes and 90 volts on the audio-frequency amplifier tubes, securing the greatest possible economy without sacrifice of signal volume.

In the case of neutrodyne circuits, however, because of the increased plate-circuit impedance resulting from reduced plate voltage, there is loss of signal strength during long distance reception when 45-volts plate potential is used instead of 90. For local reception this is not a disadvantage. As most listening is done with local stations it is desirable to have easy means at hand for changing plate voltage as required by receiving conditions. A good test clip on the radio-frequency "B" battery lead makes it a matter of a moment to change the plate voltage from 45 to 90, when long distance work is attempted. This slight effort amply justifies itself in the longer life secured from "B" batteries, if only 45 volts is used during local reception.

One measure can be applied to any neutralized radio-frequency circuit, without likelihood of causing self-oscillation. The grid return, leading from the secondary inductance to the filament, should be connected with the negative filament lead, between the rheostat and the negative side of the "A" battery. In this way the small potential drop across the filament rheostat is utilized in reducing the plate current. In a normally stable circuit this amount of negative drop is not sufficient to cause self-oscillation, yet it is sufficient to reduce the plate current to a measurable extent.

Figure 1 shows two stages of neutralized tuned-radio-frequency connected so that it draws 12 milliamperes, and Figure 2 shows the same amplifier rewired with the result that plate-current drain is reduced to about 9 milliamperes.

Radio-frequency circuits depending



upon a potentiometer to prevent self-oscillation are inherently wasteful because the function of the potentiometer is to place a positive bias upon the grids, which greatly increases the plate current. There is no remedy for this, inasmuch as even a small negative bias causes this kind of amplifier to oscillate continuously.

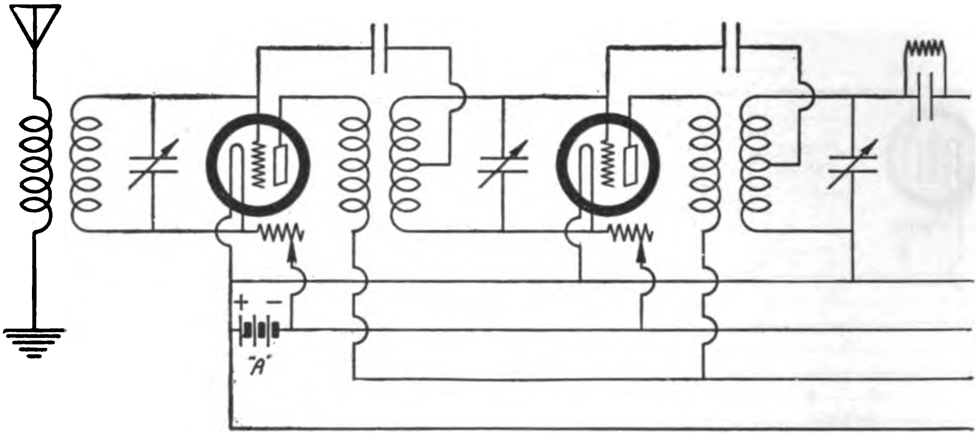
The use of moderate filament brilliancy, by cutting down filament current with the rheostat, not only reduces plate current to a marked degree but prolongs tube life and conserves filament current. The radio-frequency amplifier, handling as it does minute currents, is not improved in its effectiveness by heavy filament emission. Many receivers are therefore equipped with two filament rheostats—one for the radio-frequency tubes and the other for detector and audio-frequency amplifier tubes—so that great economy is attainable in the radio-frequency amplifier, while maximum volume output is at the same time secured from the audio-frequency end of the receiver through the use of greater filament current.

With receivers equipped with a single rheostat for all tubes it is necessary to increase the filament current for all tubes to the maximum required by the last stage of audio-frequency amplification. Since successive stages of amplification have made the variations in the last amplifier circuit large as compared with those in the first tube of the receiver, there is obviously, as the analogy in the earlier part of this article pointed out, a considerable waste of plate-battery current to use as much filament current in the radio-frequency end of the set as in the audio. On the other hand, reduction of plate current to an amount less than that required by the variations in the audio-frequency amplifier results in distortion. Two filament rheostats overcome this wasteful practice.

One habit of inexperienced listeners when receiving an excessively loud signal from a nearby broadcasting station is to reduce volume by detuning. Volume can be reduced just as effectively by reducing filament brilliancy with the filament rheostat, resulting in saving of "B" battery, "A" battery and tubes. Detuning, on the other hand, is equivalent to the practice of a motorist who attempts to reduce the speed of his car by stepping on the brakes, with the throttle still open!

The most economical method of connecting an intermediate-frequency amplifier in the superheterodyne is discussed when that circuit is taken up in detail.

To secure the greatest sensitiveness in the detector, it is necessary to place the



AN EFFICIENT NEUTRODYNE CIRCUIT

Figure 6: *In this diagram the grid returns are connected to the negative sides of the filaments in the radio-frequency amplifier and the two audio-frequency amplifiers are provided with a negative "C" battery of 4½ volts. Notice, however, that on the detector a positive grid return is correct.*

filament rheostat in the negative lead and to connect the grid return from the secondary inductance directly with the positive filament lead. Low plate voltage, however, is not only possible but desirable. Although the UV-201-a tube will operate satisfactorily as a detector with 90 volts on the plate, the most effective voltage is either 22½ or 45 volts, according to the characteristics of the particular tube.

The "C" battery should be installed in every audio-frequency amplifier. It not only substantially reduces operating costs but improves quality of reproduction as well. The negative terminal of the "C" battery goes to the grid return and the positive to the negative filament lead.

As an indication of the saving which this useful battery can achieve, its installation in a Crosley Trirdyn, for instance, reduced the plate current from 13 to 5 milliamperes; a Teledyne set has its total plate current dropped from 11 to 5 milliamperes.

In view of the long shelf-life attainable with modern "B" batteries, particularly in the larger sizes, reduction of plate current results in proportionate saving of "B" battery operating cost. Therefore any measure of economy, even with a set drawing but little plate current, is highly desirable. Now let us consider the principal kinds of receiving sets to which the economies outlined may be applied.

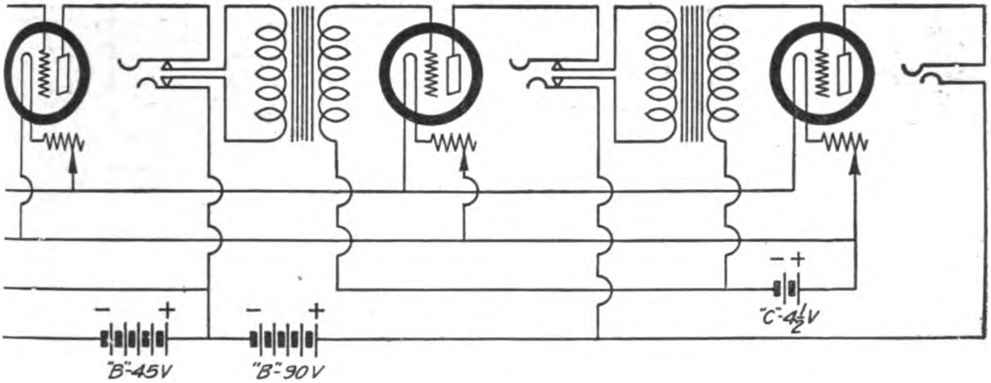
The simple regenerative receiver with two stages of audio-frequency amplification is most economical when:

1. The lowest effective voltage is used on the detector tube, through a separate "B" battery binding post for the purpose.
2. The lowest effective plate voltage is applied to the amplifier tubes to secure satisfactory volume and quality, through a separate binding post for the amplifier tube "B" battery supply.
3. 4½ volts negative bias is applied to the grids of the audio-frequency amplifier tubes.

Tuned-radio-frequency circuits, whether neutralized according to the Hazeltine method or otherwise, are most economical when hooked up as shown in the illustration, which embodies the following features:

1. Separate binding posts for detector, radio-frequency and audio-frequency amplifier plate voltage, permitting the use of the lowest effective voltage in each circuit.
2. Grid return of radio-frequency tubes connected to negative "A" battery. With the filament rheostat in the negative filament leg.
3. 4½ volts "C" battery for audio-frequency amplifier tubes.

All plate voltages should be adjusted to the lowest effective operating point. Sometimes only 45 volts is required for all tubes when listening to local stations



while best long-distance work is done with 90 volts. In that case the "B" battery lead should be equipped with a test clip so that these changes may be made conveniently and quickly.

The superheterodyne circuit is more widely abused than any other. Some home-made superheterodynes have been found which draw as high as 100 milliamperes! Yet the fullest capabilities of this circuit may be taken advantage of with a receiver drawing but 20 milliamperes or even less from the "B" battery. There is no good reason why a superheterodyne should draw substantially more current than this, and if you have one which does so it is well worth while to consider the following economy measures:

1. *In the oscillator:* (a) Do not use more than 45 volts plate potential; more than this is wasteful and unnecessary; (b) Use 1½ volts negative bias on the grid return; this substantially reduces the current drain of that part of the receiver.

2. *In the detector circuits:* (a) Do not use excessive plate voltages; 22½ is often sufficient; more than 45 is wasteful.

3. *In the intermediate-frequency amplifier:* (a) Do not use more than 45 volts plate potential; many superheterodynes use 90. (b) Use 1½ volts negative bias on the grids; this results in substantial savings.

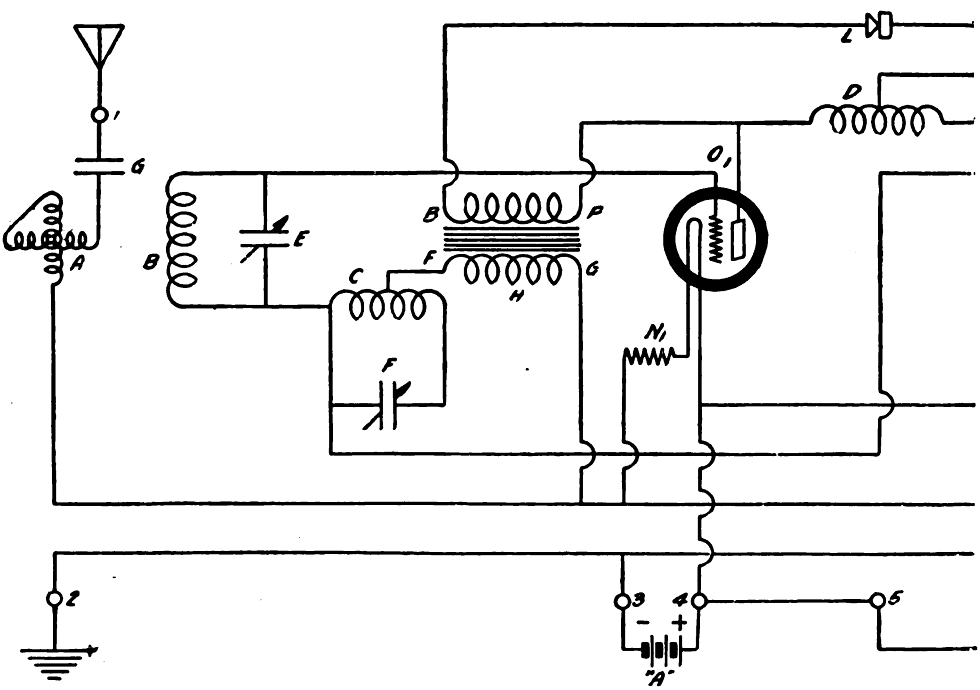
4. *In the audio-frequency amplifier:* (a) Use 4½ volts negative bias on the grid; (b) Use only as much plate potential as is necessary to secure satisfactory operation.

The circuits for two superheterodynes are shown, one as it is often built by the home constructor, and the other taking advantage of every possible economy. The first superheterodyne drew nearly 40 milliamperes; the second only 18. That ratio is somewhat better than cutting the "B" battery bill in half.

Although it would be possible to show specifically the changes necessary in a great variety of circuits to secure the utmost economy, the same principles which have been illustrated in the examples so far given can be applied to almost any circuit.

What a Straight-line Frequency Condenser Really Is

If you want to know all that goes into the production of a condenser with true straight-line frequency characteristics, what is the true worth of a low minimum capacity—and what "straight-line frequency" really means, read the article on this subject in a near issue of Popular Radio.



HOW TO BUILD THE NEW

Orthophase Radio Receiver

In this article is described for the first time a circuit development that utilizes a new principle in radio-frequency amplification. The incorporation of this new principle in a radio receiver makes possible great sensitivity; combined with both sharp tuning and ease of operation.

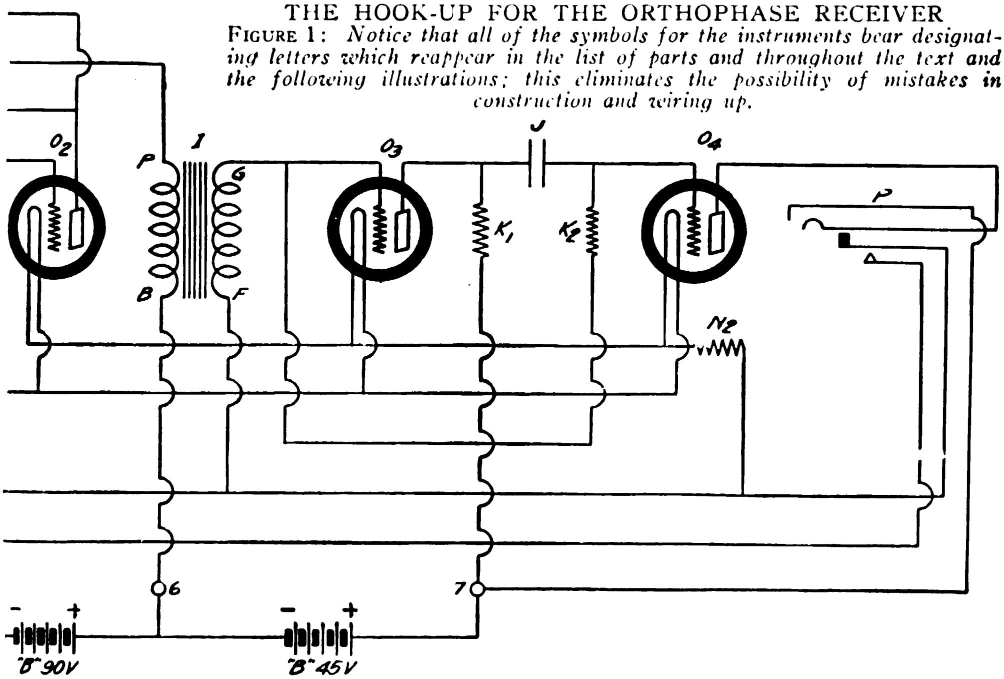
By RICHARD J. GRIFFITH

COST OF PARTS: Not more than **$55.50**

RECEIVING RANGE: *Country-wide reception*

HERE IS A LIST OF THE PARTS USED IN THE LABORATORY SET—

A—General Radio variometer, type No. 269;
B, C and D—grid coil, auxiliary coil and plate coil of Precision Orthophase coil set No. 300;
E and F—Hammarlund S. L. F. condensers, .0005 mfd.;
G—Aerovox fixed condenser, .00015 mfd.;
H—Amertran audio transformer, type AF 6, (5 to 1 ratio);
I—Pacent superaudioformer No. 27;
J—Daven resisto-coupler, (new type which has .1 mfd. condenser concealed in base);
K1—Durham or Dubilier resistance .25 megohm;
K2—Durham or Dubilier resistance .5 megohm;
L—Rasla fixed crystal detector;
M—Electrad grid-leak holder;
N1—Amperite No. 1A (¼ ampere);
N2—Amperite No. 1 (1 ampere);
O1, O2, O3 and O4—Universal sockets;
P—Carter last stage filament control jack No. 103;
Q—National velvet vernier dial, type B;
R1 and R2—Century 3-inch dials;
T—composition panel, 8 by 22 inches;
U—hardwood baseboard, (furnished with cabinet);
V—Corbett special Popular Radio sloping-panel cabinet;
W—small brass brackets. (See Figure 12);
X1—Antenna connection block, 1 inch by 2 inches. (See Figure 12);
X2—battery connection block, 1 inch by 9 inches. (See Figure 12);
Y1 and Y2—large brass brackets. (See Figure 12);
Seven Eby binding posts.



THE HOOK-UP FOR THE ORTHOPHASE RECEIVER

Figure 1: *Notice that all of the symbols for the instruments bear designating letters which reappear in the list of parts and throughout the text and the following illustrations; this eliminates the possibility of mistakes in construction and wiring up.*

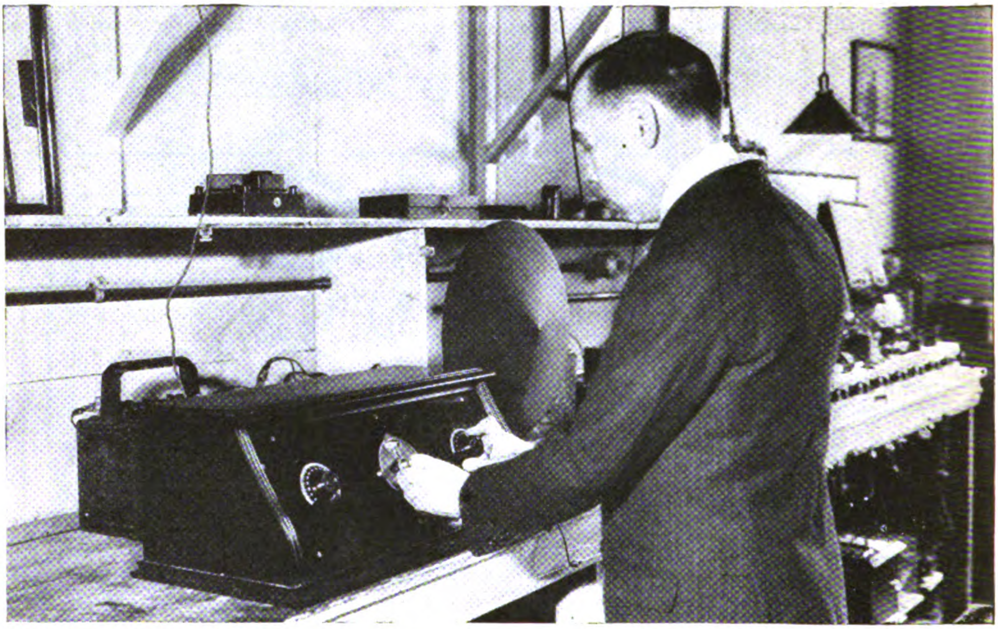
¶ *The list of parts here given includes the exact instruments used in the laboratory set, from which these specifications were made up. The experienced amateur, however, will be able to pick out other reliable makes of instruments of similar characteristics and equal efficiency. But we recommend that the novice follow the list, as the diagrams in this article will tell him exactly where to bore the holes and exactly where to place the connections. If instruments other than the ones used in the original model are used, the only change that will be necessary will be the use of different spacings for the holes that are to be drilled in the panel for mounting the instruments.*

THE radio fraternity in general, including engineers, experimenters and those to whom radio is a source of amusement and education, are almost unanimous in placing quality of reproduction at the top of the list of the most essential factors in deciding whether a receiver is good, fair or bad.

While truthful reproduction is essential, there is another property which might be considered equal to it in importance, and without which a receiver is valueless, no matter how beautifully it may reproduce the transmitted music or voice; the ability to select one station and to reproduce the broadcasting from that station, without the "background" of sounds emanating from some other unwanted station. For no matter how clear the tone quality of a receiver may be, it will be wasted if the music from two or more stations is jumbled together into a mass of dissonant noise.

In addition to tone quality and selectivity, there are, of course, other things to be considered in building or purchasing a receiver. These include sensitivity, or the ability to pick up weak signals, ease of operation and, in the case of a home-built outfit, it is desirable that a receiver be as simple and as easily built as possible.

The Orthophase receiver was designed with the purpose of securing tone quality and selectivity, for these two are



THE AUTHOR TESTS OUT THE FINAL MODEL

FIGURE 2: *One of the completed receivers set up in the laboratory for final test and calibration. Other receivers built in a similar manner by experimenters should tune at approximately the same dial settings.*

the most important of all the properties of a receiver.

Several factors help to guarantee faithful reproduction in this receiver. In the first place, the signal is detected or rectified by a crystal detector, which, as is well known, gives a true tone-portrait of the original broadcast sound. This is due, of course to the linear characteristic of the crystal rectifier. After rectification the signal must be amplified and of course the true characteristic of the rectified signal must be preserved during amplification if we are to have life-like tone-quality delivered by the loudspeaker. The amplifying system of the Orthophase has been designed to fulfill these conditions as nearly as possible. The audio-amplifying system comprises two transformer stages and one resistance-coupled stage. While an old-type transformer has been used in the first stage, no detrimental effects are observed by its use, as it follows the crystal detector and so is not subject to overloading, or saturation of its core, as there is no direct current flowing through its primary, which would be the case were it connected in the plate circuit of a tube.

In the second stage, one of the new-type large-sized transformers is used, to enable the handling of the higher power present in this stage. This transformer is designed to amplify all frequencies equally, having an especially large core to withstand saturation, and a high primary impedance so as to amplify the low tones as well as the higher ones. These two points, in connection with correctly designed secondary distributed capacity and so forth, give a high-voltage amplification, while preserving all the characteristics of the original sound.

The last audio stage is resistance-coupled, and of course, is also a quality amplifier. To enable the handling of the great power and volume at this stage a power tube is used. This avoids overloading of the last tube, which is the cause of much distortion in many amplifying systems.

The selectivity of the Orthophase Receiver is due in a large measure to the extremely loose coupling of the receiver to the antenna system and to the use of low-loss, low-resistance coils in the radio-frequency amplifying system.

The receiver also is extremely sensitive.

Another important item is ease of operation, especially to those who consider a radio receiver primarily as a musical instrument.

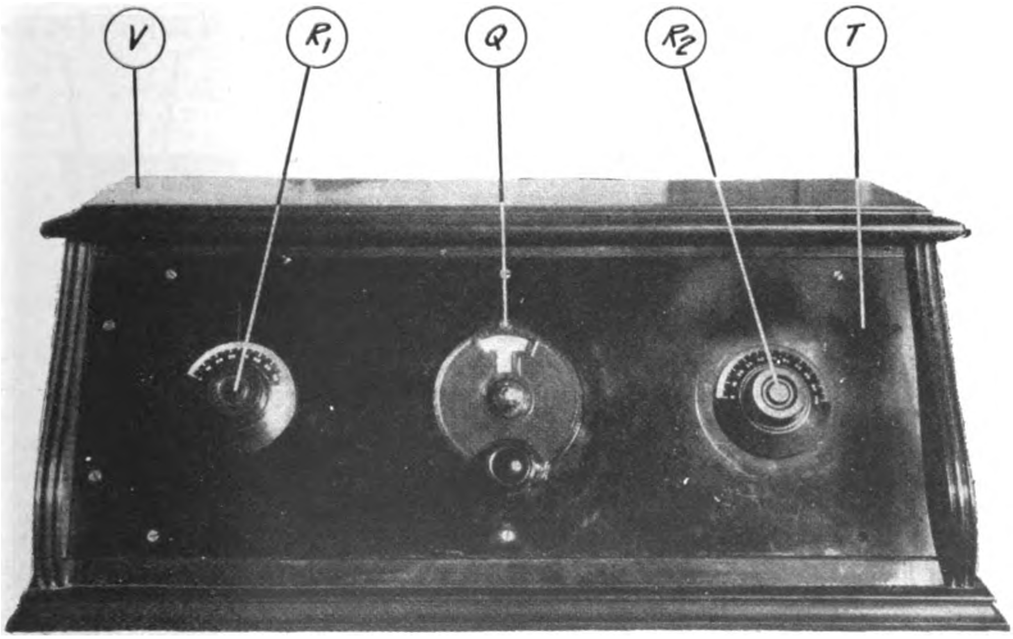
The wavelength is controlled by the middle dial, which may be calibrated and logged. The right-hand dial may be used to control the volume, or its position can also be logged, as this dial may always be set at approximately the same point as the middle or wavelength dial. The left-hand dial is used to tune the antenna circuit and is not critical in its adjustment.

Inasmuch as several principles not commonly used in radio receiving enter into the operation of the Orthophase receiver, it may be well to consider briefly the theory of its action.

Features of the Receiver

In Figure 1 it will be noted that the variometer A is in the antenna circuit and is coupled loosely to the grid-coil B. When a radio wave from a broadcasting station strikes the antenna it sets up a high-frequency oscillating current in the antenna circuit consisting of the variometer A, condenser G, antenna and ground. As the grid-coil B is coupled inductively to the variometer A, a high-frequency current will be set up in the oscillatory circuit that consists of the grid-coil B and the variable condenser E, providing this latter oscillatory circuit is tuned to resonance with the antenna circuit and the signal being received. This operation, of course, is identical with that of practically all modern receivers.

It will be noted that the grid of tube O1 is connected to the upper end* of grid-coil B, while the grid of tube O2 is connected to the lower end of the same coil. As, at any one instant, the two ends of a coil in which an alternating (or oscillating) current is flowing are at opposite potentials, it will be apparent that at the instant when the grid of tube O1 is positive the grid of tube O2 will be negative, and *vice versa*. This means that when the plate-current flow of tube O1 is *increased* due to its grid becoming positive, the plate-current flow of tube O2 is *decreased* due to its grid becoming negative. It is, of course, apparent that when the grid of tube O1 becomes *negative* and the grid of tube O2 becomes *positive*, the plate-current flow of tube O1 is decreased and



THE FRONT VIEW OF THE NEW RECEIVER

Figure 3: *How the set looks from the front. As the dials and knobs are marked with letters which correspond to the instruments to which they are attached, the prospective operator will have no trouble in locating the various tuning controls, as they are explained in the instructions for tuning.*

the plate-current flow of tube O2 is increased. In other words, the reception of a signal from a broadcasting station will simultaneously *increase* the plate-current flow of one tube and *decrease* that of the other, at one instant, and at the next instant will reverse the process. The frequency of these reversals will, of course, depend on the frequency of the signal being received.

Considering the plate-coil D, it will be noted that the left* half of it is included in the plate-circuit of tube O1 and the right half is included in the plate-circuit of tube O2. This being the case, any variation of current in the plate-circuit of tube O1 will be effective upon the left half of the plate-coil D. This variation of current flowing through the left half of the plate-coil D will set up, by induction, a current of magnified voltage in the entire winding of the plate-coil D. Similarly, any variation of current in the plate circuit of tube O2 will affect the right half of the plate coil D, and will also set up a current of magnified voltage in the entire winding. From the foregoing it will be seen that the plate-coil D is the equivalent of a transformer with a secondary and two primary windings.

It is to be noted that the plate current of tube O1 flows through the plate coil D in the reverse direction to that of tube O2. This being the case, an *increase* of current in the plate circuit of tube O1 will induce in the plate coil D a current in phase with that induced by a decrease in the current of tube O2, and vice versa. It is therefore evident that as the plate current of one tube is always increased when that of the other is decreased, the induced currents in the entire winding of the plate coil D will always be in phase and additive. These combined currents are passed through the detector L and being rectified make themselves effective upon the primary of audio transformer H as a pulsating current. This induces a voltage of audio frequency in the secondary of audio transformer H, which is applied to the grids of tubes O1 and O2. It is to be noted that as grid coil B and auxiliary coil C have a relatively small amount of inductance and practically zero impedance to audio-frequency currents, the grids may be considered as being connected in parallel to transformer H when considering audio-frequency currents.

The tubes O1 and O2 will therefore act as audio amplifiers in *parallel*, for as the plate currents of tubes O1 and O2 flow through the primary of transformer I in the same direction, the plates may also be considered as being in parallel when considering audio-frequency currents.

The secondary of audio transformer I is in the input circuit of tube O3, and since tubes O3 and O4 act as straight audio amplifiers, no explanation of their operation is necessary.

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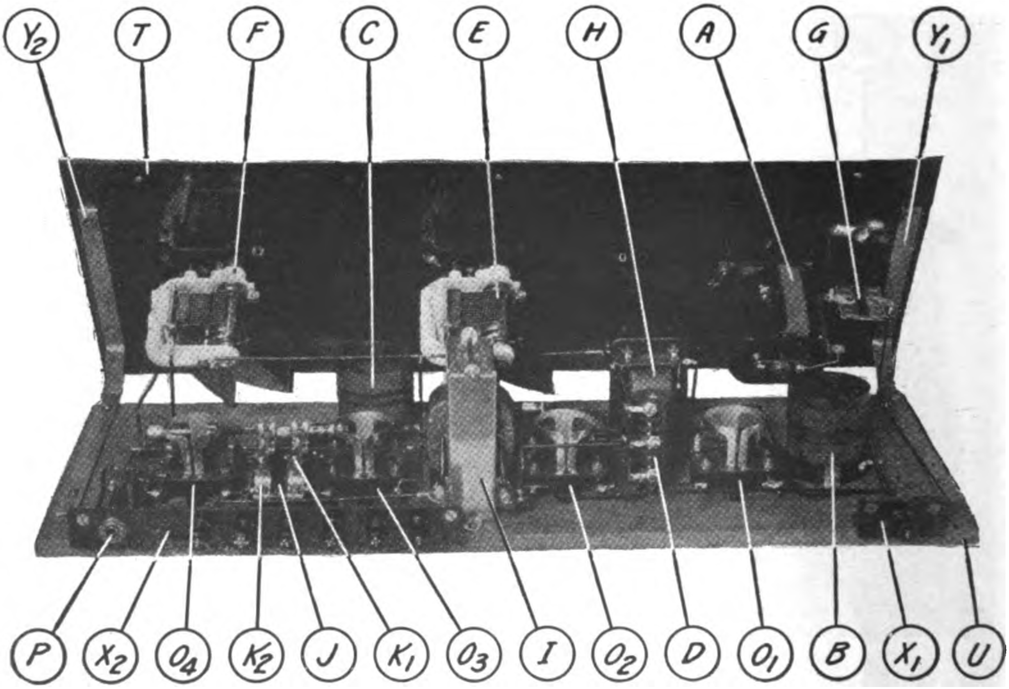
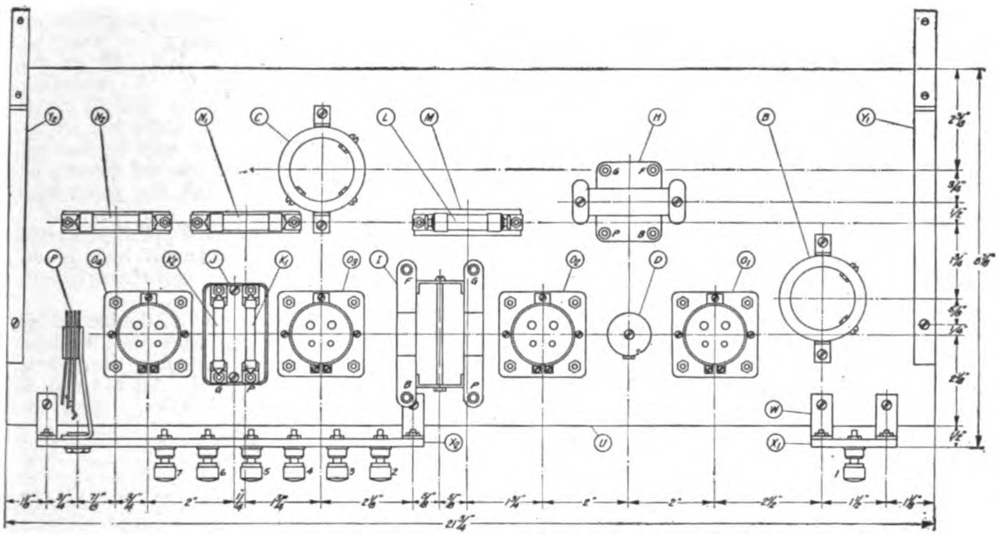
*It is to be noted that "upper," "lower," "right" and "left" refer in this case to the position on the Figure 1 and not on the receiver itself.



VIEW OF THE SET FROM THE REAR

FIGURE 4: *This picture shows the general arrangement of all the instruments fastened to the panel or base. The exact locations for the instruments are shown in Figure 5.*



THE WORKING DRAWING FOR CONSTRUCTION

FIGURE 5: *Here are shown the correct positions for the instruments which are mounted on the baseboard. The positions are given center to center, for all instruments.*

So far we have not considered the action of auxiliary coil C, as it has been assumed that it was removed or short-circuited. We have noted above that the variations of plate current through the tubes O1 and O2, due to the incoming signals, induced combined and magnified currents in the plate coil D, these currents being of the same frequency as the oscillations derived from the antenna circuit. It will be found that, due to the distributed capacity of the windings of audio transformer H, and due to the capacity between the windings, a great amount of this radio-frequency current from the plate coil D leaks into the secondary of audio-frequency transformer H, without being rectified.

It will be found that, at any one instant, if the grid of tube O1 assumes a positive charge (and consequently the grid of tube O2 assumes a negative charge) a potential of positive sign appears at the left-hand end of the secondary of audio transformer H. During the other half of the cycle it will assume a negative potential, it being noted that at any instant the radio-frequency potential of terminal F- of transformer H is the same as that of grid O1 and opposite to that of grid O2.

To simplify matters we will consider the action of auxiliary coil C when the grid of tube O1 becomes positive and the grid of tube O2 becomes negative. As the potential at the F- terminal of audio transformer H is the same as grid O1, it will also be positive at this instant. Now, in the absence of auxiliary coil C, this reflexed *positive* charge would be applied *directly* to the grid of tube O2, whose potential at this instant is *negative*, due to the oscillations from the antenna. It will be seen that these potentials would tend to nullify or neutralize one another.

Similarly, in the absence of the auxiliary coil C, the reflexed positive potential being applied to the grid of tube O1 through the resonant circuit comprising the grid coil B and the condenser E, would have its sign reversed and would be applied to grid O1 as a negative charge. The grid O1 at this instant being positive, these potentials would nullify one another as in tube O2.

We will now consider the action of the reflexed potential when the auxiliary coil C is included in the circuit. The reflexed radio-frequency potential at F- of transformer H, which we assumed to be positive at this instant, is applied to the grid of tube O2 through the resonant circuit comprising auxiliary coil C and condenser F. This circuit, being resonant to the frequency of the reflexed radio-frequency current, will cause a considerable voltage to be built up, the phase of the reflexed radio-frequency current will be reversed, and instead of a positive potential, a higher negative potential will be applied to grid O2, and as the grid of tube O2 is already negative (at this instant), due to the incoming signal, this reflexed potential will reinforce the potential derived from the antenna.

Similarly, the original reflexed positive potential will have its sign reversed to negative by auxiliary coil C and reversed back to positive by the grid coil B and will be applied as a magnified positive potential to grid O1, reinforcing the positive potential already on grid O1 due to the incoming signal.

With the theory of the action of the Orthophase circuit in mind, it is felt that it will be much easier to build and operate the receiver described in this article, and we may now proceed with the actual construction.

The schematic diagram is shown in **Figure 1.**

Parts Used in Building the Set

In all the diagrams in this article each part bears a designating letter; in this way, the prospective builder of a set may easily determine how to mount the instruments in the correct places and connect them properly in the electric circuit.

The same designating letters are used in the text and in the list of parts at the beginning of the article. (See page 142.)

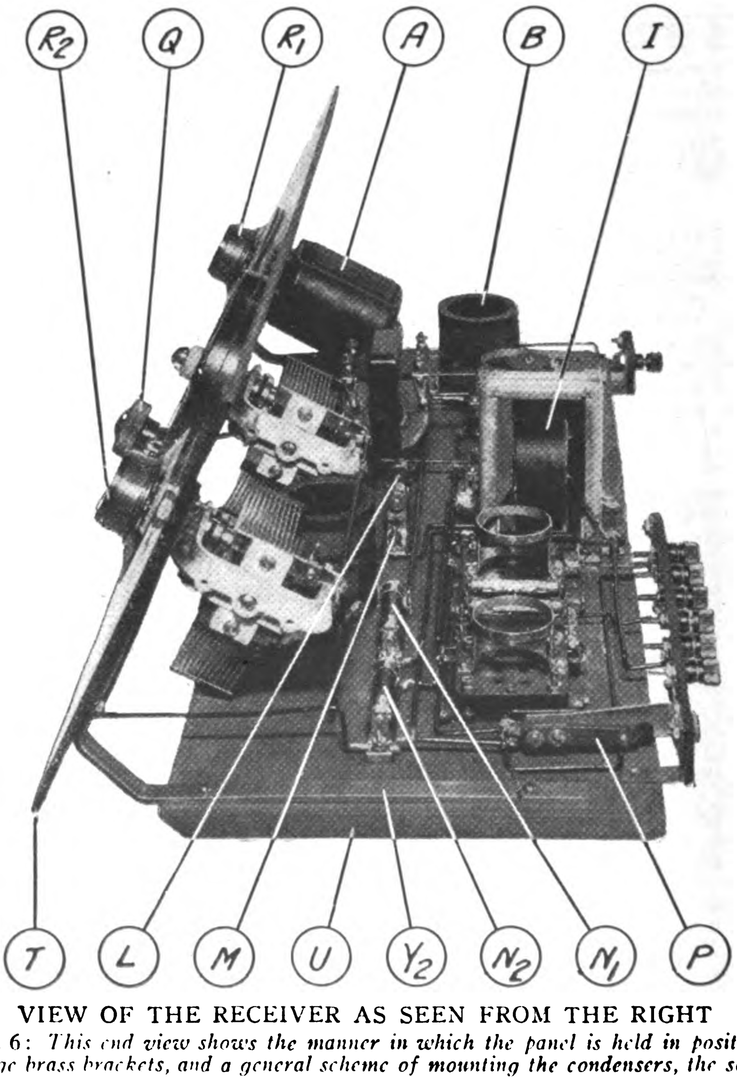
How to Construct the Set

After procuring all the instruments and materials for building the set, the amateur should prepare the panel T. (Shown in Figures 4, 5, 6 and 7.)

First of all, cut the panel to the correct size, 8 by 22 inches. Then square up the edges smoothly with a file. The centers for boring the holes (which are necessary for mounting the instruments) should be laid out on the panel as shown in Figure 9. A convenient method for doing this is to lay out all center holes on a piece of paper the same size as the panel; then the piece of paper may be fastened on the panel and the centers marked directly on the panel by punching through the paper with a sharp, pointed instrument.

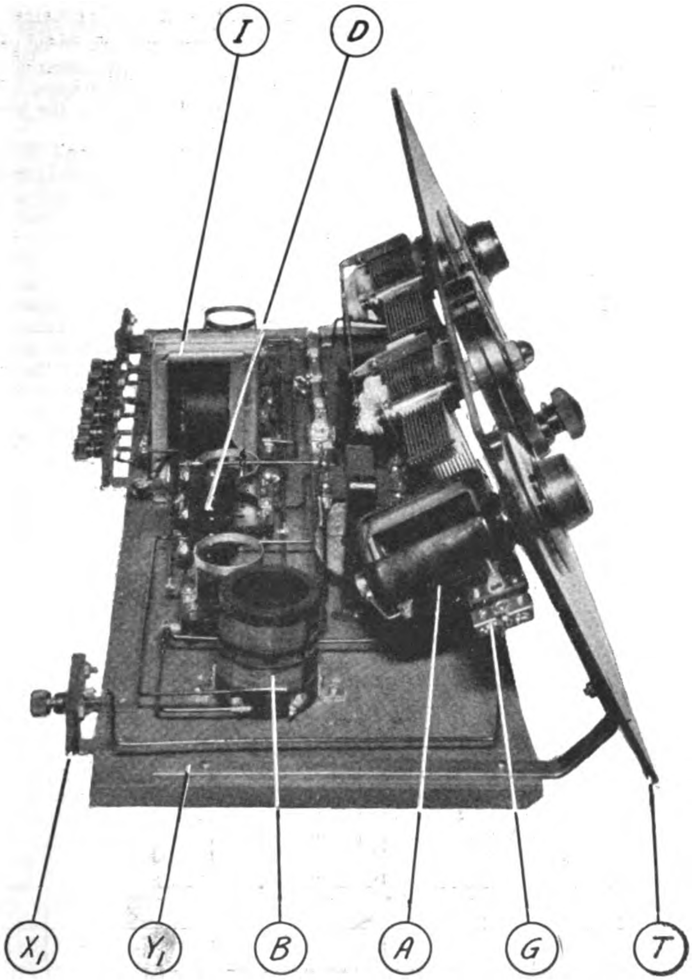
If all the holes to be drilled are first started with a small drill, one sixteenth inch in diameter or less, they can be more nearly centered.

The holes outlined with a double circle should be countersunk, so that the flat-head machine screws used for fastening the instruments are flush with the panel. All the rest of the holes are straight drill holes. Sizes for



VIEW OF THE RECEIVER AS SEEN FROM THE RIGHT

FIGURE 6: *This end view shows the manner in which the panel is held in position by the large brass brackets, and a general scheme of mounting the condensers, the sockets, the transformers and the battery connection block.*



VIEW OF THE RECEIVER AS SEEN FROM THE LEFT

FIGURE 7: *This illustration shows the general manner of mounting the radio-frequency transformer, the variometer and the antenna connection block.*

the diameters of these holes have not been given, but the builder will readily decide what size hole is necessary by measuring the diameter of the screws and shafts of the instruments that must go through the holes.

When the panel is drilled, the builder may give it a dull finish by rubbing the face of the panel lengthwise with fine sandpaper until it is smooth. This process should be repeated, except that light machine oil should be applied during the second rubbing. Then rub the panel dry with a piece of cheesecloth. A permanent dull finish will be the result. Or, the panel may be left with its original shiny-black finish, if care has been exercised, so that it has not been scratched during the drilling.

After the panel has been prepared the experimenter is ready to mount the instruments on it.

First, attach the fixed condenser G to the variometer A by inserting the screw through the condenser lug and into the threaded terminal lug nearest the front or panel end of the variometer. (See Figures 4 and 8.)

Now, mount the variometer A on the panel T by means of two screws and nuts inserted through the panel. (See Figure 4). Make sure the two terminal lugs on the stator point *away* from the center of the panel (See Figure 8).

Then attach the dial R1 as follows: First turn the rotor of the variometer so that the front rotor lead points upward, then slip the dial onto the shaft, with the 100 mark opposite the indicating mark on the panel and tighten up the set screw in the dial. Next mount the variable condensers E and F on the panel, so that the rotor plates will swing upward when they are not meshed. (Shown in Figures 4, 6, 7 and 8). Now attach the dial R2 to condenser F by tightening the set screw in the dial, making sure that the 100 mark on the dial is opposite the indicating mark on the panel when the plates of the condenser are meshed.

After this attach the vernier dial Q to condenser E as follows: Fasten the stop pin, which is supplied with the dial, to the panel and then place the dial on the condenser shaft, making sure that the stop-pin engages the hole at the top of the dial on the reverse side. Then, with the condenser plates meshed and the dial set to the 100 degree mark, tighten up the set screw in the dial, making sure the dial is flush against the panel.

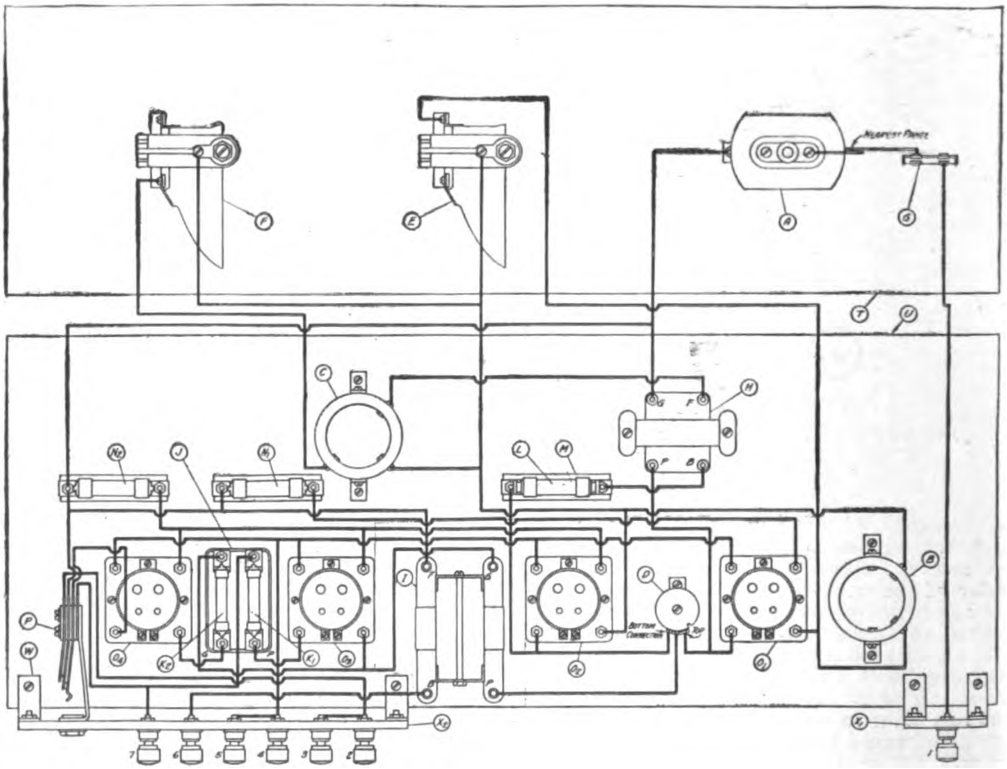
This completes the construction work on the panel and the experimenter is ready to mount the instruments on the baseboard. The baseboard is supplied with the cabinet, and it should be taken out and the instruments mounted on it as shown in Figure 5 which is the working drawing for construction.

First mount the four sockets 01, 02, 03 and 04 in their respective places as shown in Figures 4, 5, 6 and 7 with the F terminals at the front.

Next attach the amperites N1 and N2 in their respective places as shown clearly in Figure 5. All these instruments are to be screwed directly to the baseboard. Next fasten down the resisto-coupler J as shown in Figure 5. Be sure the terminal marked P is next the similarly marked terminal on socket 03.

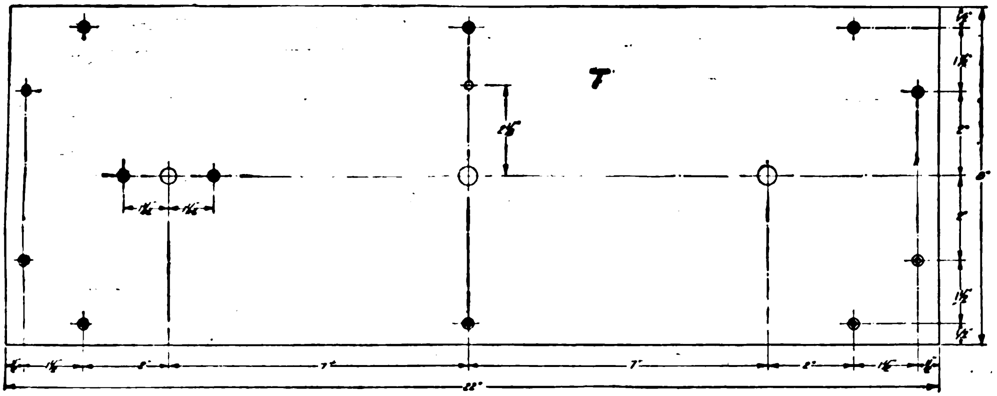
Next mount the grid coil B in the position shown in Figures 4, 5, 6 and 7, fastening it down with two small screws inserted through the holes in the brackets at the bottom of the coil. Be sure that the two terminals of the coil point away from the socket O1. Now, mount the auxiliary coil C in the same manner, in its correct position as shown by Figures 4, 5, 6 and 7, making sure that two terminals point to the right and the single terminal points to the left when looking at the rear of the set. (See Figure 8). Next mount the plate coil D, by noting its position in Figures 4, 5, 6 and 7, with the terminals at the rear of the set, and pointing to the left, when looking at the rear of the set.

Now mount the grid leak holder M in its correct position as shown in Figures 4, 5, 6 and 7, by screwing it down to the baseboard. Then mount the audio-frequency transformer H in



THE PICTURE DIAGRAM FOR CONNECTING UP THE VARIOUS INSTRUMENTS

Figure 8: *The upper rectangle represents the panel and on it the instruments are drawn just as they appear. The lower rectangle represents the baseboard and the instruments are drawn in about their relative positions. The wires drawn in heavy black lines show the exact way to run the wires to connect the instruments and parts after you have mounted them according to the instructions given.*



THE DRILLING PLAN FOR THE PANEL

FIGURE 9: *This drawing shows where to drill the holes for mounting the instruments. The correct spacings are given for the holes. The holes outlined with a double circle should be countersunk. Always start drilling holes in the panel with a small drill—one-sixteenth is a desirable size.*

place as shown in Figures 4, 5, 6 and 7, being sure the terminals are pointing in the direction indicated in Figure 5. The Superaudioformer I is mounted in the same manner, with like attention being paid to its terminals.

When this is done, the work on the baseboard may be left for a while and the two connection blocks X1 and X2 (the dimensions of which are shown in Figure 12), should be prepared and the binding posts attached. The small brass brackets may then also be screwed tight to the blocks and the jack P mounted on the larger block X2.

Now fasten down the two blocks X1 and X2, on the sub-base U by means of four screws inserted through the brass brackets into the baseboard. Their position may be found on Figure 5.

Then prepare the two large brass brackets Y1 and Y2, which are to be used for attaching the main panel T to the base U at the proper angle; the dimensions for these angles including the drilling and bending are also shown in Figure 13. Be sure that you have the angles made with the correct drilling holes and bends so that the panel will fit evenly. Then mount the panel in position on the brackets. This had best be done by slipping the baseboard U in position in the cabinet with the brackets Y1 and Y2 attached and then fastening the panel in position with four screws.

You are now ready to start on the wiring as the construction work is completed.

How to Wire the Set

The design of this receiver is such that the wiring of the grid circuit of each of the four tubes is as short as possible and is isolated from the other parts of the circuit. In fact, this idea has been employed throughout and the leads are so arranged that the shortest connections may be used. As this is the case, the set should be wired with bus bar.

Either a tinned-copper, round bus-bar or an insulated round bus-bar such as "Celatsite" may be used for the connection. All connections should first be shaped so that they will fit. They should then be soldered in place. Refer to the wiring diagram in Figure 1 and more specifically to the picture diagram in Figure 8 for the exact way in which to run the wires.

Start the wiring by running a wire from binding post No. 1 to the end of condenser G not attached to the variometer A.

Next run a wire from binding post No. 2 to binding post No. 3 and continue it over to the extreme left-hand* spring of the jack P. Now run a wire from the second spring from the left of the jack P to the left end of Amperite N2. Then run an extension of this wire to the left end of the Amperite N1 and continue it over to the F- terminal of transformer I.

Now going back to the left end of Amperite N2; run a wire from this point over to the panel and parallel to same, connecting it to the left-hand screw of the bracket that holds the variometer A to the panel. Now extend this wire over to the G terminal of the transformer H.

Next run a wire connecting the left front terminals of all the sockets O1, O2, O3 and O4 together. (These are the F+ terminals of the sockets.) Now run a wire from the left front terminal of socket O3 to binding post No. 4 and also extend it to binding post No. 5. This last wire should be run between socket O3 and the resisto-coupler J.

Now run a wire from the right-hand end of Amperite N2 to the front right-hand terminal of the socket O4 and run an extension of this wire to the front right-hand terminals of the sockets O3 and O2.

Next, run a lead from the right-hand end of Amperite N1 to the front right-hand F terminal of the socket O1. Then, run a wire from binding post No. 6 to the B terminal of transformer I.

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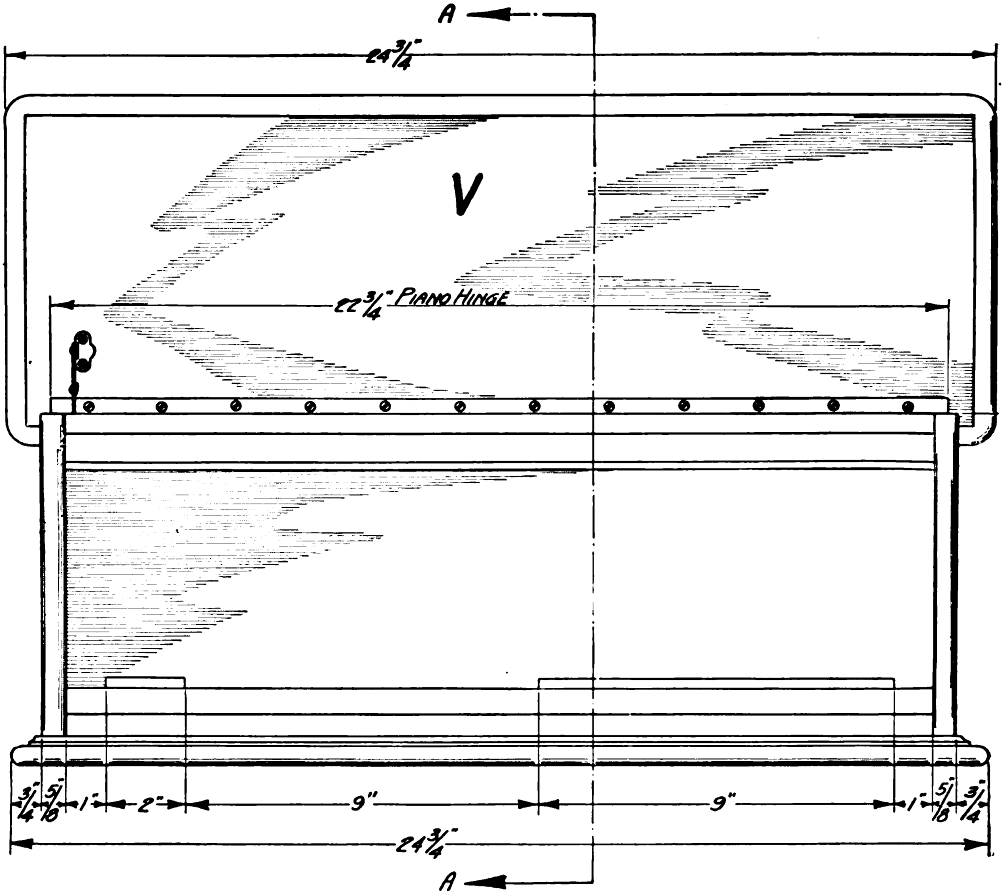
*The front connection on any instrument refers to the side of the instrument nearest the panel and right and left refer to the constructor's right and left as he sits facing the back of the set in wiring up.



After this, run a wire from binding post No. 7 to the right-hand connection or frame of the jack P. Also run an extension of this wire to the B terminal of the resisto-coupler J.

Now connect the middle or remaining spring of the jack P to the P terminal of the socket O4.

Next connect the G terminal of the socket O4 to the G terminal of the resisto-coupler J, and connect the P terminal of the resisto-coupler J to the P terminal of the socket O3. These last three connections are very short.

Now, run a lead from the G terminal of the socket O3, between the socket O3 and the transformer I, and around to the G terminal on transformer I. Next run an extension from this point over to the F terminal of the resisto-coupler J.

Next, connect the terminal marked P on the transformer I to the center terminal of the plate coil D.

Now connect the bottom terminal of the plate coil D to the terminal marked P on the socket O2. Then run an extension of this wire to the left end of the grid leak holder M, taking care to keep this last lead at least a quarter of an inch from the core of transformer I. The lead should run between socket O2 and transformer I. After this, run a wire from the right-hand end of grid-leak holder M to the terminal of transformer H, which is marked B.

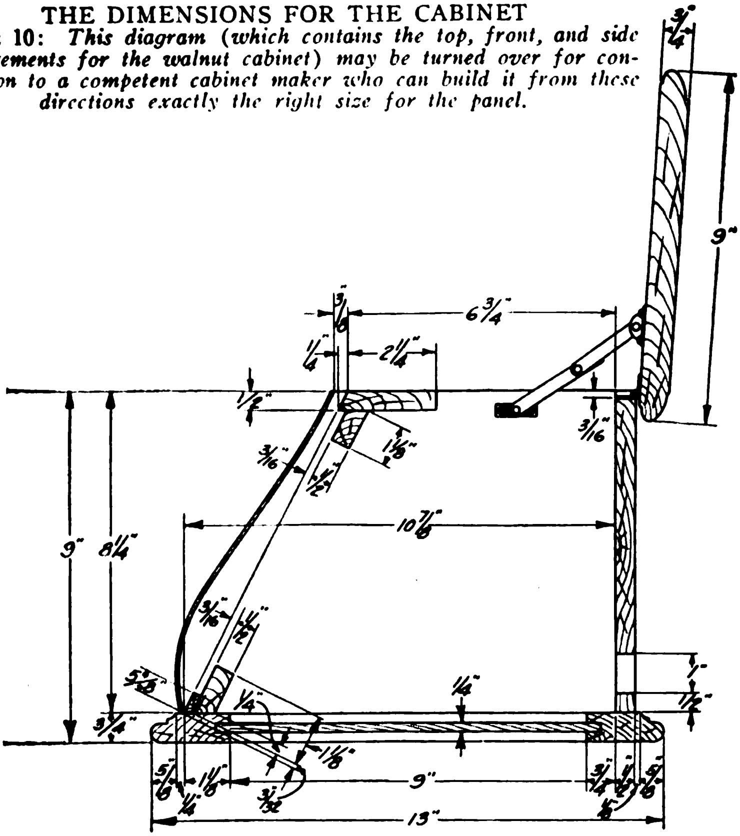
Then run a lead from the terminal marked P on the transformer H to the top connection of plate coil D. Next, run an extension of this lead from here to the terminal marked P on the socket O1. Now, run a wire from the rear connection of the grid coil B to the G terminal on the socket O1. Then run an extension of this wire, between the grid coil B and the socket O1, connecting it to the lower stator terminal of the variable condenser E. Make sure this lead is kept one-half inch from the transformer H.

Next connect the front terminal of the grid coil B to the grid terminal (marked G) on the socket O2. Then extend this lead, between the socket O2 and the plate coil D, between the grid-leak holder M and the transformer H, and connect it to the rotor terminal of the condenser E. Then run a further extension over to the rotor of the condenser F. After this run a wire from the rear right-hand terminal of the auxiliary coil C, directly up and solder it on the lead running from the rotor of condenser E to the rotor of condenser F.

Next connect the rear left-hand terminal of auxiliary coil C to the upper stator connection of the condenser F.

THE DIMENSIONS FOR THE CABINET

Figure 10: ***This diagram (which contains the top, front, and side measurements for the walnut cabinet) may be turned over for construction to a competent cabinet maker who can build it from these directions exactly the right size for the panel.***



SECTION THRU A-A

Then, run a lead from the front right-hand connection of auxiliary coil C to the F terminal on the transformer H.

The set being now completely wired, is ready for installation.

How to Install the Set

The set should first be inserted into the cabinet. In placing the set in the cabinet, grasp the baseboard and slowly slide the set into the cabinet. Make sure the two connection blocks X1 and X2 fit into the openings cut in the back of the cabinet and then push the whole unit back into place, so that you can screw in the six wood screws that hold the panel in place.

Then place the Amperite N1 (No. 1A) in the left-hand holder (as you look at the front of the set), and N2 (No. 1) in the right-hand holder. Place the two Durham resistance units in the resisto-coupler J, putting the .5 megohm in the left-hand clip (as you look at the front). After this insert the crystal detector L in the grid-leak holder M and tighten up the two thumb nuts on the detector.

Next, place a UX-201-a or a UV-201-a tube in each of the three sockets O1, O2 and O3, and in socket O4 place a UX-112 power tube. The batteries, antenna and ground connections are now ready to be attached. If you are using the set with an outside antenna of sixty feet or more, simply connect the antenna to binding post No. 1. If you are using a short indoor antenna of fifteen or twenty feet, the condenser G should be short-circuited.

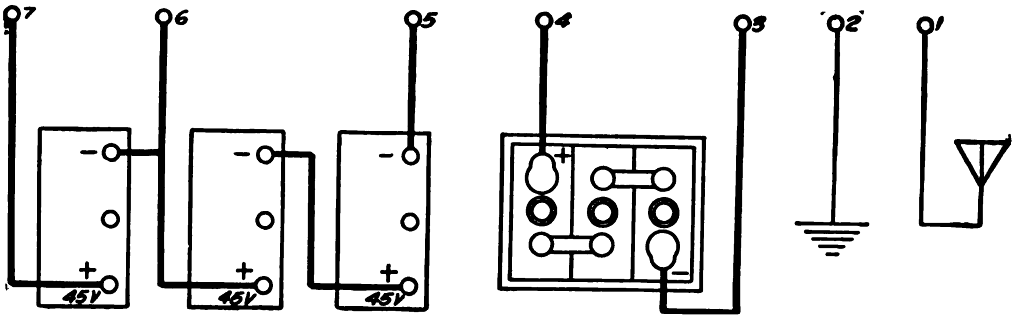
Connect the batteries and ground connections as shown in Figure 11. Next insert the loud-speaker plug into the jack P and the set is ready for use.

Operating Data

It will be best to tune in a number of local stations to become acquainted with the set. Turn the dial Q to the setting indicated by the tuning chart in Figure 13.

Next turn dial R2 until a humming noise is heard and then turn back dial R2 until the quality of the received music is restored. It will be noted that the humming referred to always occurs when dial R2 is at approximately the same setting as dial Q.

After this adjust dial R1 until maximum volume and quality are secured. If the volume is too great turn dial R2 back toward the zero mark, and if more reduction is desired adjust dial R1 to another setting.



HOW TO HOOK UP THE BATTERIES

FIGURE 11: *This drawing prevents the builder from making mistakes in connecting the batteries to the terminals of the receiver. Follow these instructions and the set will be hooked up correctly, because the terminals shown in the wiring diagrams are marked with designations that correspond with the numbers given here.*

In searching for distant stations, dial Q may be revolved slowly from zero to the maximum, at the same time turning dial R2 at the same rate of speed, keeping the latter dial at a setting *just below* that which produces the humming. If desired, stations may be located by means of the "carrier-wave-beat note" method, which is commonly used in tuning ordinary regenerative receivers.

Once the station is located, its volume may be improved as outlined above for local stations and if desired the settings of the dials logged for future reference, although it is not necessary to log any except dial Q.

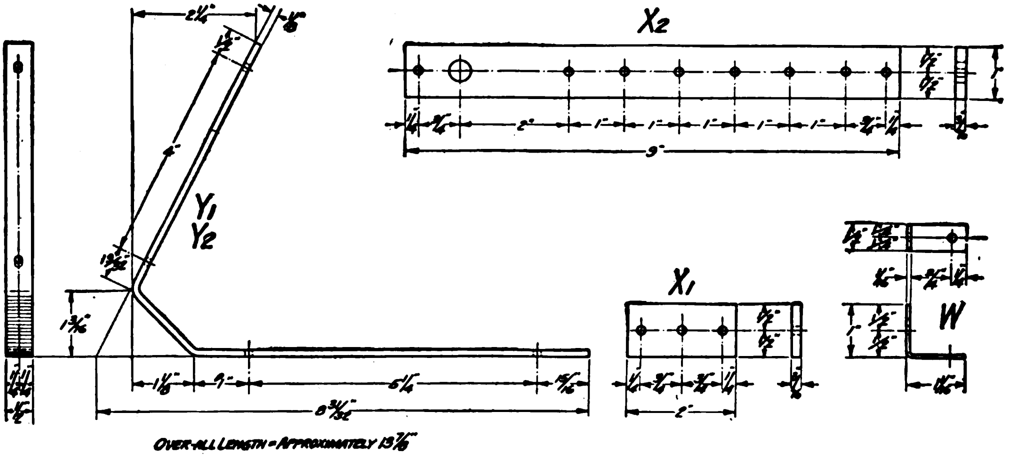
In turning off the set it is necessary only to withdraw the loudspeaker plug from the jack P and the current supply to the filaments is automatically cut off.

An Orthophase receiver similar to the one herein described has consistently received Pacific Coast stations in New York City on a short indoor antenna of fifteen feet, in all but the poorest radio weather, when the static level was too high to permit tuning the receiver to its most sensitive condition.

Of course, it is understood that wherever possible an antenna of 60 feet to 120 feet should be used, as less critical tuning is required to secure equal results.

In periods of heavy static the antenna may be disconnected entirely, and by shifting the ground wire from binding post No. 2 to binding post No. 1, satisfactory results may be had, on local reception and also on distant reception in most localities. The condenser G must be short-circuited in this case.

Regarding selectivity, it might be well to mention that KFI in Los Angeles has been tuned in in New York City, while WJZ in New York and WCAP in Washington, D. C., were in operation. By referring to the wavelengths of these three stations, the remarkable selectivity of the Orthophase will be apparent, the above being only one example of this quality.



DETAILS OF THE BRASS BRACKETS AND THE CONNECTION BLOCKS

FIGURE 12: *This drawing gives the necessary data for making the insulated blocks on which the binding posts are to be mounted; it also gives the dimensions for the large and small brass brackets that are used to fasten the large and small panels to the baseboard.*

A Tuning Chart to Adjust to Your Own Set

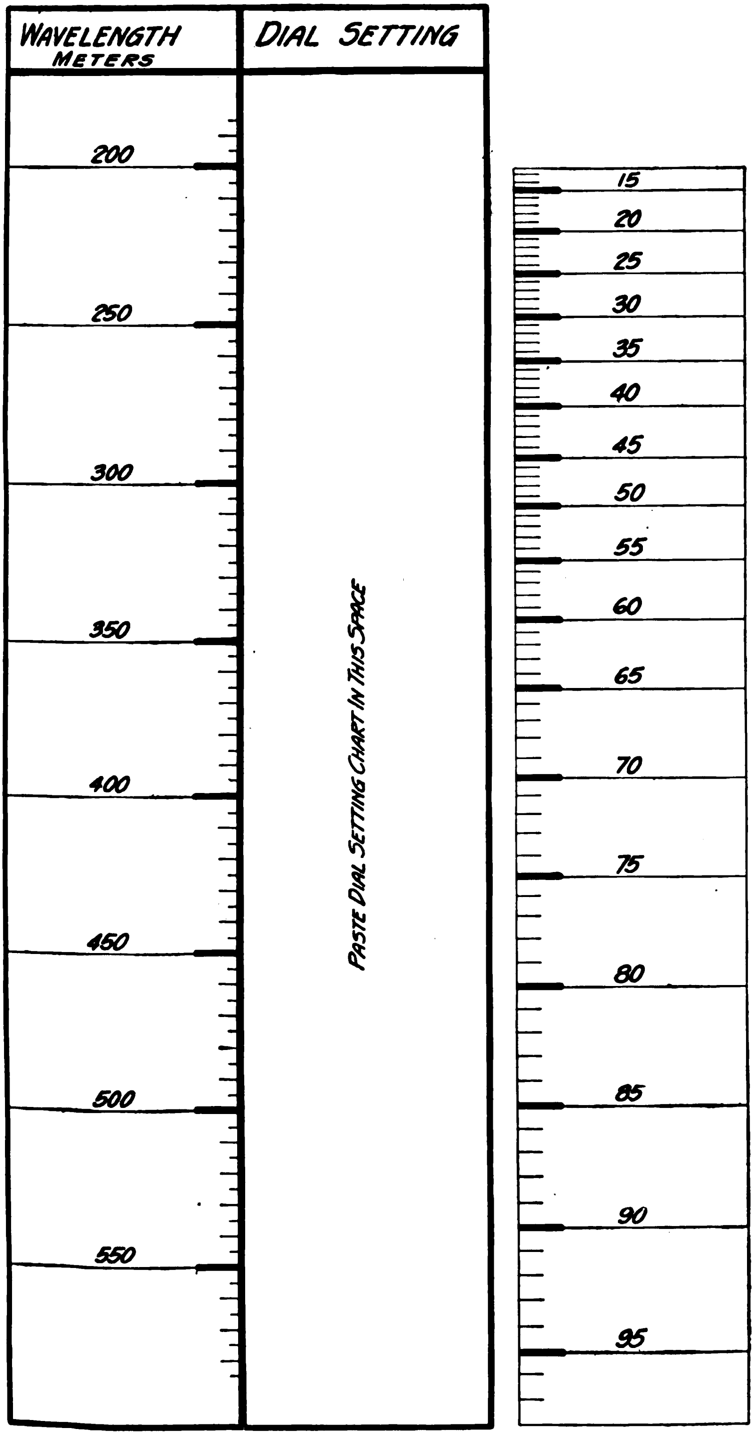
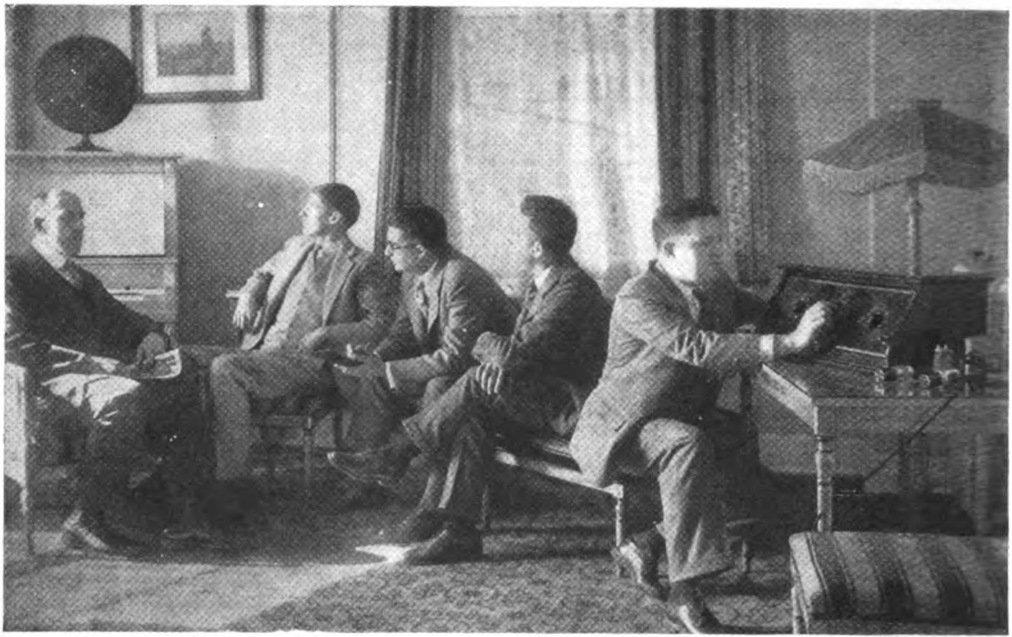


FIGURE 13: *Cut out the chart at the left and paste it on a piece of thin, stiff, white, bristol paper. Then cut out the small chart at the right. It should be pasted in position on the blank space on the right-hand side of the main chart underneath the heading "Dial Setting." To get it in exactly the right position tune in a station of around 350 to 450 meters and find out what setting it comes in on on your dial. For instance, a station on 405 meters would come in somewhere near 72, 73 or 74 on your dial according to the variation of the condenser in the set. If it comes in at 73 (say), paste the dial setting part of the chart in place so that 405 meters on the wavelength scale is exactly opposite 73 on the dial setting scale. Then all the other stations will tune in exactly as indicated by the completed chart.*



From a photograph made for POPULAR RADIO

AN OPERATING TEST ON THE NEW RECEIVER

In this photograph is pictured the installation of the LC-26 receiver in the Washington Hotel at Washington, D. C., during the reception of distant stations. A cone-type loudspeaker was used. The designer of the circuit is shown tuning in the various broadcasters while the author writes down the call letters as verified by the listeners.

Country-wide Tests of the New LC-26 Receiver

Here are given the results of the reception on the receiver first described in the December issue of POPULAR RADIO as installed in various sections of the country and operated before authoritative witnesses. Can you match these records with your own receiver? Anyone with a LC-26 set should be able to do it.

By WALTER L. RAYMOND

THE description of the construction of the LC-26 Broadcast Receiver in the December issue of POPULAR RADIO created such widespread interest among experimenters and set builders that it was followed by another article in the January issue with complete details of operation of this set.

Since then, however, so many letters have been received asking about the results that could be obtained in different sections of the country that the staff of POPULAR RADIO has taken one of its receivers to various cities and operated it in the presence of witnesses to determine just what the receiver would do under varying local conditions.

The first test was conducted at New Haven, Conn., at the home of Mr. William Austin, Jr. The receiver was set up and attached to a 100-foot single-wire antenna that was already installed in connection with a Four-circuit Tuner. The new LC-26 receiver was installed in its place and a record made on the receiver starting at 11 o'clock in the morning.

Not only was this well known "dead spot," (so far as New York stations are concerned), overcome, but the following New York stations were brought in with approximately the same volume as when received in New York City:

WFBH
WRNY
WJZ
WOR
WMCA
WEAF
WNYC

The receiver also brought in on the loudspeaker, stations:

WOO, *Philadelphia,* Pa.
WPG, *Atlantic City,* N. J.
WBZ, *Springfield,* Mass.
WEEI, *Boston,* Mass.
KDKA, *Pittsburgh,* Pa.
WGY, *Schenectady,* N. Y.

An almost unbelievable distance record for the daytime was also made in bringing in station WMBF in Florida before 4 o'clock in the afternoon.

The list of stations received during the evening comprised stations in the Middle West and Canada and as far south as Miami.

The New York stations were received clearly on the loudspeaker by using just the ground alone.

The next test was made in New York City before a group of well known engineers. In one complete revolution of the tuning dial from zero to 100, the following stations were picked up in succession:

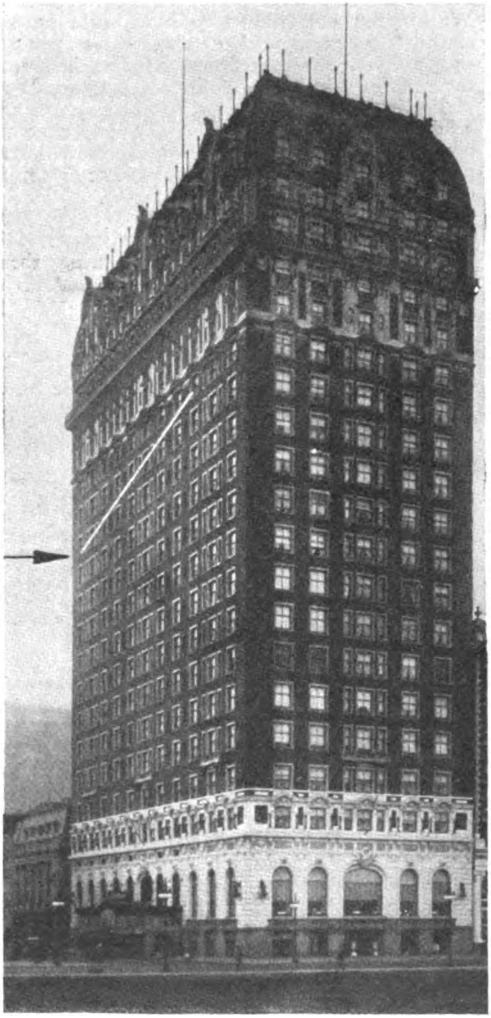
WSBC (at 209.7 meters)
WOK, *Chicago,* Ill.
WBBR, *New York,* N. Y.
WGCP, *New York,* N. Y.
WRNY, *New York,* N. Y.
WAAM, *New York,* N. Y.
WEBJ, *New York,* N. Y.
WFBH, *New York,* N. Y.
WEEI, *Boston,* Mass.
WOAN, *Lawrenceburg,* Tenn.
WPG. *Atlantic City,* N. J.
WLIB, *Chicago,* Ill.
KDKA, *Pittsburgh,* Pa.
WJAR, *Providence,* R. I.
WAHG, *New York,* N. Y.
KOA, *Denver,* Col.
WSAI, *Cincinnati,* O.
WBZ, *Springfield,* Mass.
WMCA, *New York,* N. Y.
WHN, *New York,* N. Y.
WEBH. *Chicago,* Ill.
WGY, *Schenectady,* N. Y.
WMBF, *Miami,* Fla.
WEAR, *Cleveland,* O.
WTAM, *Cleveland,* O.
WFI, *Philadelphia,* Pa.
WJY. *New York,* N. Y.
WLW, *Cincinnati,* O.
WSB, *Atlanta,* Ga.
WMAF, *South Dartmouth,* Mass.
WJZ, *New York,* N. Y.
WCAE, *Pittsburgh,* Pa.
WRC. *Washington,* D. C.
WBAP, *Ft. Worth,* Tex.
WOC. *Davenport,* Ia.
WEAF, *New York,* N. Y.
WOO, *Philadelphia,* Pa.
WNYC, *New York,* N. Y.
KYW, *Chicago,* Ill.
KSD (at 546 meters)

This makes a total of 40 stations in twenty-five different cities, located throughout the United States. These stations were all received when using an outside antenna of about 110 feet in length. The reception was accomplished entirely on a loudspeaker.

A more thorough test at New York City lasting for two days between the hours of 11:30 P. M. and 1:30 A. M. Eastern Standard Time was made and the following stations were logged:

WCBD, *Zion City,* Ill.
WIP, *Philadelphia,* Pa.
WGR, *Buffalo,* N. Y.
KPRC. *Houston,* Tex.
WCAD. *Canton,* N. Y.
WOC. *Davenport,* Ia.
WBAP, *Ft. Worth,* Tex.
KFKX, *Hastings,* Nebr.
KLX, *Oakland,* Cal.
WEAR, *Cleveland,* O.
WHT, *Chicago,* Ill.
KFI. *Los Angeles,* Cal.
WRC, *Washington,* D. C.
WBZ, *Springfield,* Mass.
KDKA, *Pittsburgh,* Pa.
WJR, *Pontiac,* Mich.
WLW, *Cincinnati,* O.
KOA, *Denver,* Colo.
KGO, *Oakland,* Cal.
WQJ, *Chicago,* Ill.
KYW, *Chicago,* Ill.
KSD, *St. Louis,* Mo.
WCAU, *Philadelphia,* Pa.
WCAE, *Pittsburgh,* Pa.
CHYC. *Montreal,* P. Q.
WNAC, *Boston,* Mass.
WEAN, *Providence,* R. I.
WKRC. *Cincinnati,* O.
WFI, *Philadelphia,* Pa.
WSB, *Atlanta,* Ga.
WJAR, *Providence,* R. I.
PWX. *Cuba*
WPG. *Atlantic City,* N. J.
WEBH. *Chicago,* Ill.
WREO, *Lansing,* Mich.
WHT, *Chicago,* Ill.
WHO, *Des Moines,* Ia.
WQI. *Chicago,* Ill.
WSM. *Nashville,* Tenn.
WENR, *Chicago,* Ill.
WMAQ, *Chicago,* Ill.
WHAZ, *Troy,* N. Y.
CFCF, *Montreal,* P. Q.
WDZ. *Tascola,* Ill.
WOAN, *Lawrenceburg,* Tenn.
WGY. *Schenectady,* N. Y.
WHAM, *Rochester,* N. Y.
WGN, *Chicago,* Ill.
WEEI, *Boston,* Mass.
WSMB, *New Orleans,* La.
WOK, *Chicago,* Ill.
WLIT, *Philadelphia,* Pa.
WCCO, *St. Paul-Minneapolis,* Minn.
WFAA, *Dallas,* Tex.
WLS, *Chicago,* Ill.
WCX, *Pontiac,* Mich.
WWJ, *Detroit,* Mich.
WLIB, *Chicago,* Ill.
CNRO, *Ottawa,* P. Q.
WHB. *Kansas City,* Mo.
WOAW, *Omaha,* Nebr.
CKAC, *Montreal,* P. Q.
WCAP, *Washington,* D. C.
BM, *Chicago,* Ill.
WMAF, *South Dartmouth,* Mass.
WSAI, *Cincinnati,* O.
WMC, *Memphis,* Tenn.
WMBF, *Miami,* Fla.
WOO, *Philadelphia,* Pa.
WTIC, *Hartford,* Conn.
WGBU, *Fulford-by-the-Sea,* Fla.
WGN, *Chicago,* Ill.
WOS, *Jefferson City,* Mo.
WWAE, *Plainville,* Ill.

In a test in the same city for operation through interference the following stations



Brown Bros.

THE ANTENNA INSTALLATION

In this picture of the Blackstone Hotel in Chicago is shown the exact location of the single-wire antenna that was swung from one window to another during the tests. The antenna is shown by the white line and the lead-in was located by the point indicated by the black arrow.

were logged without interruption from nearby stations: WGN, of Chicago, was received through WHN; WHT was received through WJY; WIP of Philadelphia and WOC of Davenport were received through stations WEAF and WNYC, New York. KYW was also received through WNYC. Station WQJ in Chicago was received through WJZ, New York. Stations WPG, WJAR, WLIB and KDKA could also be received without interference while all of them were on the air.

The next test was made in Washington at the Washington Hotel. Mr. Cockaday, who was a member of the Hoover Radio Conference and the author took one of the sets to Washington and set it up in a suite on the eighth floor and had a single-wire antenna rigged up on the roof about 120 feet including the lead-in. In daylight at Washington, WJZ and WEAF were brought in clearly on the loudspeaker and also the new experimental super-power station 2XAR of the Radio Corporation of America. These were received during their noon-hour broadcasting.

The Washington Hotel itself is only about three blocks from WCAP in Washington. The following stations were logged during three evenings:

WEBH, *Chicago,* Ill.
WBBM, *Chicago,* Ill.
WOK, *Chicago,* Ill.
WHT, *Chicago,* Ill.
WLIB, *Chicago,* Ill.
NAA, *Washington,* D. C.
WLW, *Cincinnati,* O.
KOA, *Denver,* Colo.
WEAF, *New York,* N. Y.
WIP, *Philadelphia,* Pa.
WBZ, *Springfield,* Mass.
WFI, *Philadelphia,* Pa.
WCAP, *Washington,* D. C.
WRC, *Washington,* D. C.
KDKA, *Pittsburgh,* Pa.
WRCA, *Richmond,* Va.
WJZ, *New York,* N. Y.
WMCA, *New York,* N. Y.
WMBF, *Miami Beach,* Fla.
2XAR, *Bound Brook,* N.J.
WEEI, *Boston,* Mass.
WJBL, *Decatur,* Ill.
WSM, *Nashville,* Tenn.
WSMB, *New Orleans,* La.
WHAZ, *Troy,* N. Y.
WSB, *Atlanta,* Ga.
WCAE, *Pittsburgh,* Pa.
WCX, *Pontiac,* Mich.
WJR, *Pontiac,* Mich.
WHO, *Des Moines,* Ia.
WFBH, *New York,* N. Y.
KOIL, *Council Bluffs,* Ia.
WLIT, *Philadelphia,* Pa.
WAHG, *New York,* N. Y.
WFI, *Philadelphia,* Pa.
KYW, *Chicago,* Ill.
WSAI, *Cincinnati,* O.
WOR, *Newark,* N. J.
WOAN, *Lawrenceburg,* Tenn.
WBAP, *Fort Worth,* Tex.
WOAW, *Omaha,* Nebr.
WTAM, *Cleveland,* O.
KFKX, *Hastings,* Nebr.
WOO, *Philadelphia,* Pa.
WGY, *Schenectady,* N. Y.
WDAF, *Kansas City,* Mo.
KGW, *Portland,* Ore.

It will be noticed that the country was pretty well covered from Washington.

The last test was made in Chicago at the Blackstone Hotel, which is located only two blocks from the powerful Westinghouse station KYW. A 100-foot wire was installed along the ledge of the windows on the tenth floor of this building, which has twenty-two floors in all. A wire was brought into the living room and attached to the LC-26 with the steam radiator pipe used as a ground.

The following list of out-of-town stations was received during the week of tests between the hours of 11:30 P. M. and 2 A. M. Central Standard Time:

KDKA, *Pittsburgh,* Pa.
WPG, *Atlantic City,* N. J.
WSMB, *New Orleans,* La.
WGR, *Buffalo,* N. Y.
WSAI, *Cincinnati,* O.
WGAZ, *South Bend,* Ind.
KTHS, *Hot Springs,* Ark.
WHAZ, *Troy,* N. Y.
WTAM, *Cleveland,* O.
WOR, *Newark,* N. J.
WSB, *Atlanta,* Ga.
WOS, *Jefferson City,* Mo.
WCAE, *Pittsburgh,* Pa.
WBAP, *Fort Worth,* Tex.
WEAF, *New York,* N. Y.
WJR, *Detroit,* Mich.
WHO, *Des Moines,* Ia.
WSUI, *Iowa City,* Ia.
WAHG, *Richmond Hill,* N. Y.
WSM, *Nashville,* Tenn.
WLIB, *Elgin,* Ill.
WCX, *Detroit,* Mich.
WFAA, *Dallas,* Tex.
KPRC, *Houston,* Tex.
KFI, *Los Angeles,* Calif.
WEAH, *Wichita,* Kan.
WJJD, *Mooseheart,* Ill.
WKAR, *Lansing,* Mich.
WBAP, *Ft. Worth,* Tex.
WRC, *Washington,* D. C.
WOC, *Davenport,* Ia.
WJR, *Detroit,* Mich.
WOAW, *Omaha,* Nebr.
WLW, *Cincinnati,* O.
KFI, *Los Angeles,* Calif.
WKRC, *Cincinnati,* O.
WHB, *Kansas City,* Mo.
WBAP, *Ft. Worth,* Tex.
WFBC, *Knoxville,* Tenn.
WCAU, *Philadelphia,* Pa.
WSBT, *South Bend,* Ind.
WDAF, *Kansas City,* Mo.
KYW, *Chicago,* Ill.
KFKX, *Hastings,* Nebr.
KFNF, *Shenandoah,* Ia.
WAFB, *Port Huron,* Mich.
KNX, *Hollywood,* Calif.

The following Chicago stations were received without interference from KYW:

WSBC
WENR
WQJ
WBBM
WOK
WIBO
WGES
WBCN
WMAQ
WHT
WLS
WMBB
WGN
WEBH

Stations KDKA in Pittsburgh; WBAP Forth Worth; WPG Atlantic City; WAHG Richmond Hill, New York, were received while KYW was broadcasting.

Stations WOC Davenport; WEAF New York; KDKA Pittsburgh; WLW Cincinnati and WHB Kansas City were received in the middle of the day.

One station whose call letters were not obtained was heard through great static, talking in Spanish. This station finally signed off by announcing in English that the time was 11:35. The time in Chicago (C. S. T.) was 12:35 A. M. This station signed off with chimes.

This series of tests conducted by engineers of POPULAR RADIO's technical staff and witnessed by other reliable authorities on radio reception should be of interest to radio fans and experimenters all over the country who wish to satisfy themselves of the selectivity and sensitiveness of the new receiver.

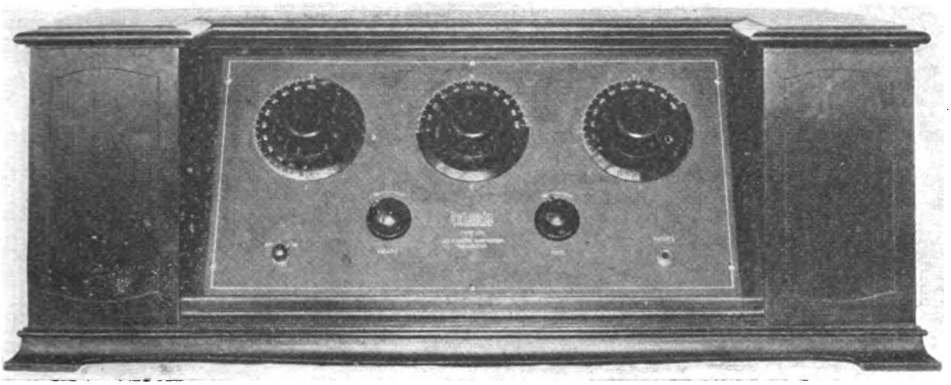
Use Popular Radio Blue Prints in Building the Orthophase Receiver

WHILE *experienced set-builders will be able to construct the Orthophase Receiver (described in this issue) from the description and design shown in the article, it will be found much easier if* POPULAR RADIO *blue prints are used. These prints save time because the panel and instrument layout prints (which are exact size) may be used as templates, thus eliminating the necessity of making careful measurements for drilling holes and locating instruments. The wiring diagram is approximately exact size; it shows the location of all wires and connections desirable for greatest efficiency. A set of blue prints of the Orthophase Receiver will be sent postpaid on receipt of $1.00 per set sent to* POPULAR RADIO SERVICE BUREAU, 627 *West 43rd Street, New York City.*

"What Set Shall I Buy?"

A guide to the prospective buyer of a ready-made receiver

LESS then a year ago there were only a very few ready-made sets on the market; today there are about 140, ranging from small and inexpensive crystal receivers, which sell for as low as four or five dollars, to elaborate superheterodynes that run into the hundreds. Those that have been approved by the POPULAR RADIO LABORATORY will be pictured each month until the series is completed. They will be accompanied by brief but specific data concerning them—as a helpful guide to the broadcast listener and to the prospective listener who is thinking of selecting the receiver that will best meet his special needs as well as the limitations imposed by his purse. The data following each of the sets pictured in this series are the manufacturers own specifications and claims; they were obtained through a form of questionnaire sent to all manufacturers of receiving sets approved by POPULAR RADIO.



The Type 100 Receiver

MANUFACTURER'S NAME; Music Master Corporation

MODEL NUMBER; Type 100

NUMBER OF TUBES; five

TYPE OF TUNING; tuned-radio-frequency

TYPE OF DETECTOR; vacuum tube

RANGE ON PHONES; (none specified)

RANGE ON LOUDSPEAKER; (none specified)

COST; $100.00 (without accessories)

ANTENNA RECOMMENDED; outside, 65 to 100 feet

KIND OF TUBES FOR R. F.; Music Master A Type or UV-201-a

DETECTOR TUBE; Music Master A Type or UV-201-a

AUDIO TUBES; Music Master A Type or UV-201-a

TYPE OF "A" BATTERY; Music Master storage 6 volts 90-amp. hour

TYPE OF "B" BATTERY; Music Master, two blocks of 45 volts each

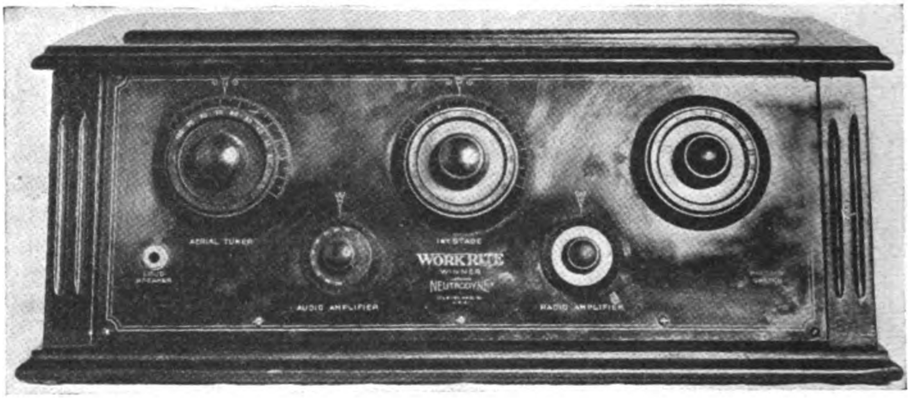
DETECTOR "B" VOLTAGE; 45 volts

WAVELENGTH RANGE; 195 to 560 meters

NUMBER OF TUNING CONTROLS; three

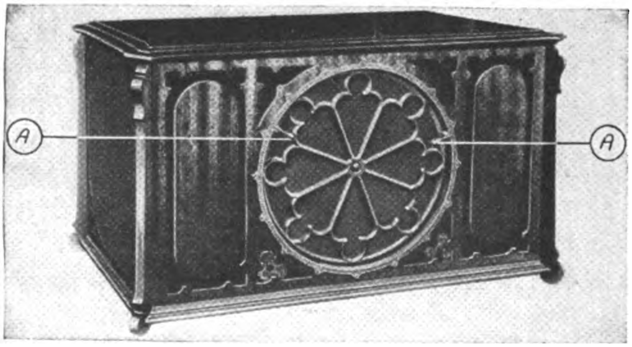
"A" BATTERY CURRENT USED; 1¼ amperes

"B" BATTERY CURRENT USED; 8 to 10 milliamperes



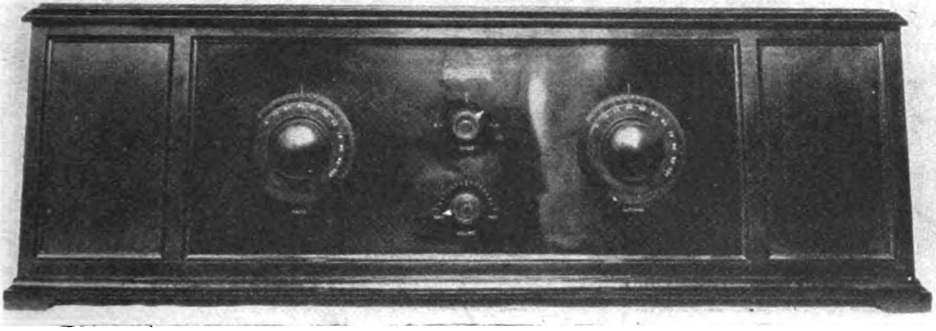
The WorkRite Winner

Manufacturer's Name; WorkRite Mfg. Co.
Model Name; WorkRite Winner
Number of Tubes; five
Type of Tuning; tuned-radio-frequency (neutrodyne)
Type of Detector; vacuum tube
Range on Phones; coast to coast
Range on Loudspeaker; coast to coast
Cost Complete; $100.00 to $125.00
Antenna Recommended; 50 feet, outside
Kind of Tubes for R. F.; 201-a
Detector Tube; 201-a
Audio Tubes; 201-a
Type of "A" Battery; 6-volt storage
Type of "B" Battery; 90 volts
Detector "B" Voltage; 45 volts
Wavelength Range; 200 to 550 meters
Number of Tuning Controls; three
"A" Battery Current Used; 1.25 amperes
"B" Battery Current Used; about 15 milliamperes



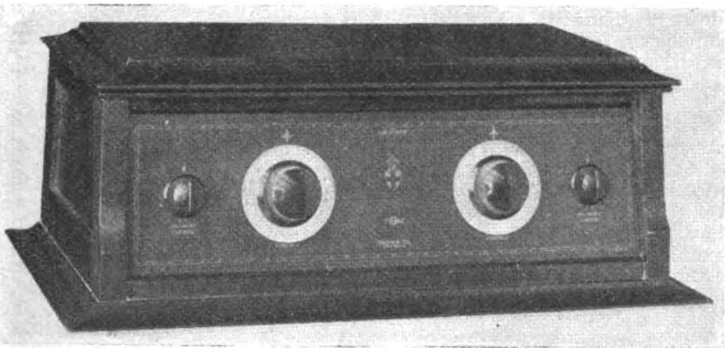
The Model L-3 Ultradyne

Manufacturer's Name; Phenix Radio Corporation
Model Name; Model L-3 Ultradyne
Number of Tubes; six
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; 1,000 to 2,000 miles
Range on Loudspeaker; 500 to 1,000 miles
Cost Complete; $185.00
Antenna Recommended; indoor or outdoor (single wire)
Kind of Tubes for R. F.; UV-201-a
Detector Tube; UV-201-a
Audio Tubes; UV-201-a
Type of "A" Battery; storage (6 volts)
Type of "B" Battery; dry cell
Detector "B" Voltage; 90 volts
Wavelength Range; 180 to 560 meters
Number of Tuning Controls; two
"A" Battery Current Used; 1½ amperes
"B" Battery Current Used; 20 milliamperes



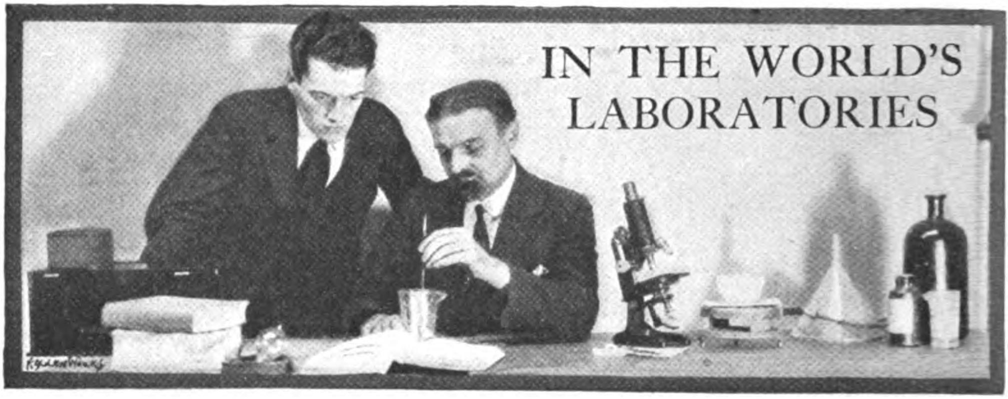
The Ferguson Six

Manufacturer's Name; J. B. Ferguson, Incorporated
Model Name; Ferguson Six
Number of Tubes; six
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; (none specified)
Range on Loudspeaker; (none specified)
Cost Complete; $180.00
Antenna Recommended; outdoor
Kind of Tubes for R. F.; UV-201-a or C-301-a
Detector Tube; UV-201-a or C-301-a
Audio Tubes; UV-201-a or C-301-a
Type of "A" Battery; 6 volt storage
Type of "B" Battery; 90 volts dry cell
Detector "B" Voltage; 22½ to 45 volts
Wavelength Range; 200 to 550 meters
Number of Tuning Controls; two
"A" Battery Current Used; 1.5 amperes
"B" Battery Current Used; 25 milliamperes



The Goldfinch

Manufacturer's Name; Guthrie Company
Model; Goldfinch
Number of Tubes; five
Type of Tuning; tuned-radio-frequency
Type of Detector; vacuum tube
Range on Phones; transcontinental
Range on Loudspeaker; transcontinental
Cost; $75.00 (without accessories)
Antenna Recommended; 80 feet
Kind of Tubes for R. F.; hard
Detector Tube; hard or soft
Audio Tubes; hard
Type of "A" Battery; 6-volt
Type of "B" Battery; any type
Detector "B" Voltage; 20 to 60 volts
Wavelength Range; 200 to 700 meters
Number of Tuning Controls; two
"A" Battery Current Used; 1.25 amperes
"B" Battery Current Used; 13 milliamperes



IN THE WORLD'S LABORATORIES

CONDUCTED BY DR. E. E. FREE

Millikan's Ultra-short Rays from Space

IN the last issue of this Department we wrote of Professor Skobeltzyn's measurements of the "shortest" ether waves ever measured, those coming from the exploding atoms of radioactive materials. Before the item was off the press Dr. R. A. Millikan, the distinguished physicist who now heads the California Institute of Technology, at Pasadena, announced to the National Academy of Sciences, meeting at Madison, Wisconsin, his discovery of a kind of ether waves far shorter than those measured by Professor Skobeltzyn or by anyone else; about one fiftieth as long, in fact, as any ether waves previously known.* Thus does the progress of investigation dispose of the most careful generalizations. Nothing remains for long the "shortest" or the "longest" or the "fastest" of science.

Professor Millikan's new rays were detected, not in or from any material on earth, but coming from the depths of space. Back of their final detection there is a long story of patient investigation. Nearly a quarter of a century ago investigators noticed that some variety of very short ether waves were present in the atmosphere. For example, these waves would penetrate the metal cases of instruments and cause the discharge of electric charges inside them. They came to be called, on this account, the "penetrating radiation" of the atmosphere. It was known that a small amount of radioactive material is present in the soil and in the air. Most scientists believed, therefore, that the penetrating radiation was composed of gamma rays from these radio-active materials; that it consisted, merely, of very short radium rays such as those measured by Professor Skobeltzyn and others.

About ten years ago, however, two German physicists, Kohlhorster and Hess made observations from balloons and reached the conclusion that there was more of this penetrating radiation in the air at high altitudes than at the surface of the earth. They suspected, therefore, the continual arrival from space of some extremely short variety of ether waves. Several scientists repeated this work under other conditions and failed to confirm it. The war intervened and all such work was interrupted.

After the war, Dr. Millikan, among others, took up once more the investigation of this mysterious penetrating radiation. He sent recording instruments up in airplanes and in sounding balloons. With an assistant, he went himself to the top of Pike's Peak, in Colorado, taking with him the apparatus for investigation of the penetrating rays. All this work was either negative or inconclusive. The reality of the penetrating ray remained unproved. Finally, in the summer of last year, Dr. Millikan and one of his assistants, Mr. Harvey Cameron, carried out an ingenious series of experiments in which radiation-detecting apparatus was sunk at different depths in two snow-fed lakes high in the mountains of California.

The height of these lakes above the sea decreased the layer of air above them, so that the penetrating rays would not be absorbed; for, penetrating as they are, these rays will not traverse any large amount of matter, even of matter as thin as air is. At the same time, the water of the lakes absorbed any stray gamma rays which might be coming from the surrounding soil. The lakes being snow-fed, their water was not itself radioactive, as many spring and river waters are.

The experiment was a success. The penetrating rays were detected. Their difference in penetrating power in the two lakes corresponded exactly with the difference in elevation of the lakes and thus with the different absorbing power of the layers of air above them. The penetration of the rays enabled, also, an estimate of their wavelength. Dr. Millikan's figure for the shortest waves is .0004

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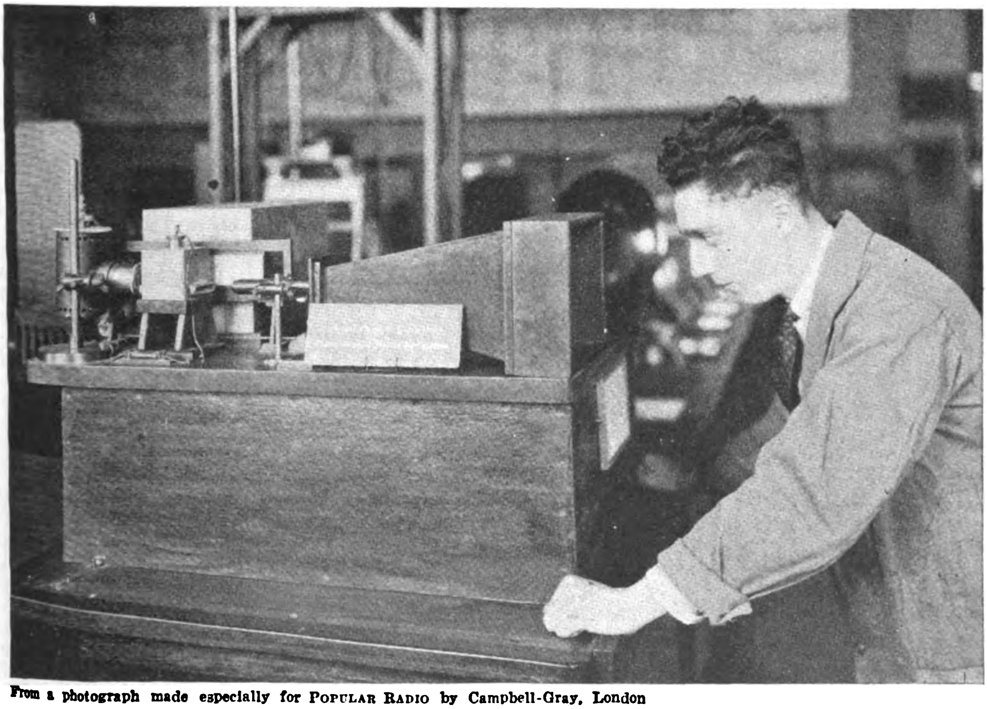
*"High Frequency Rays of Cosmic Origin," by R. A. Millikan. *Science* (Lancaster Penna), vol. 62, pages 445-448 (November 20, 1925). The address to the National Academy of Sciences was delivered on November 9, 1925.

Angstrom unit, this unit being, you remember, the one commonly used to measure the wavelength of light. It is one ten-billionth of a meter, which means that the wavelength of the newly discovered ray—which will be named, doubtless, the Millikan ray—is only one twenty-five-trillionth of a meter. The discovery of these rays lengthens the known spectrum of ether waves by nearly six octaves.

The source of the rays remains a mystery. The fact that they are the same by night as by day rules out the sun as a source. The relation to depth in the two lakes appears to be a conclusive proof that they come from space. Calculation indicates that the wavelength of the shortest of the new rays is about that which ought to be possessed by radiation produced when four atoms of hydrogen combine to form one atom of helium, an atomic combination which physicists suppose, on quite other grounds, to be possible in the stars and perhaps elsewhere in space. Another atomic change which might produce these very short waves is that which would occur when a free electron and a free proton (the positive nucleus) combine to form an atom of hydrogen. Whatever be the exact source of the rays, it is reasonably certain, Dr. Millikan believes, that they originate in some transformation of atomic nuclei which is occurring all through space.

Readers of POPULAR RADIO will remember that the idea of a very short variety of ether waves, far shorter than any then known, was postulated, some years ago, by Dr. Felix Michaud, of Paris, to explain the facts of gravitation.* Gravitational forces are due, Dr. Michaud believed, to the absorption of these pervasive, space-rays by matter. Two bodies in space partially shield each other from the rays and are therefore forced toward each other. Although the new Millikan rays lie in the region of the ether-wave spectrum in which Dr. Michaud expected to find his gravitational rays, it is not apparent, as yet, that they furnish much support to the theories of the distinguished Parisian physicist. The Millikan ray is apparently too feeble, as well as too easily absorbed by matter, to satisfy the conditions which a gravitational ray must meet. It remains possible, however, that still other and shorter rays exist. The ether-wave theory of gravitation is by no means disproved.



From a photograph made especially for POPULAR RADIO by Campbell-Gray, London

TESTING THE PENETRATING POWER OF GAMMA RAYS

Before the discovery of Dr. Millikan's new rays, the gamma rays from radium were the shortest and most penetrating ether waves known. At the Science Exhibition at Wembly, near London, last summer, the National Physical Laboratory contributed this apparatus demonstrating the gamma rays given off by radio-active material inside the lead box behind the electroscope at the left. This photograph and the one on page 169 of this issue are published by special permission of the British Empire Exhibition Committee of the Royal Society.

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* For an account of these theories see: "Do Ether Waves Cause Gravitation?" POPULAR RADIO for December, 1923, vol. 4, pages 468-477.

Filaments That Emit Ions

A RECENT scientific discovery, made by Dr. C. H. Kunsman and his colleagues at the Fixed-Nitrogen Research Laboratory, at Washington, may prove, it is by no means impossible, one of the really important steps forward in radio technique.[*] It is too soon to be sure of this. Dr. Kunsman does not even describe his discovery as a radio one at all. Nevertheless, it is not too much to say that it has a chance of proving to be quite as important to radio as was the invention of the audion tube.

The discovery is of a convenient and apparently reasonably permanent source of positive ions, just as the hot filament of an ordinary radio tube constitutes a source of negative electrons.

A positive ion consists, you remember, of an atom which has lost, temporarily, one of its electron planets. The atom then has a positive charge. In the familiar sodion detector tube, for example, the operation of the tube depends upon the presence in it of a cloud of ions of sodium. Each of these ions is really an atom of sodium gas which has had its outermost electron knocked off. The atom is then short one electron, which means one unit of negative electricity. It carries, therefore, one unit of positive charge. Normally, of course, the atom is neutral, the positive electricity of the nucleus of the atom being just neutralized by the negative electrons present in the atomic structure.[†]

From a photograph made especially for POPULAR RADIO

THE NEW IONIC TUBE

Dr. Kunsman is holding a special vacuum tube (not for radio use) containing the new filament material which emits ions instead of electrons and which is described on this page.

In the sodion tube, the ions are produced by the impacts of fast-moving electrons on sodium atoms or by the collisions of sodium atoms with each other. Ions can be produced, also, in other ways. There has not been available, however, any source of these ions which was either so convenient or so dependable as the hot filament is as a source of electrons.

Dr. Kunsman has provided this. He finds that a hot mixture of iron and an alkali metal oxide, such as potassium oxide, will give off a continual stream of alkali ions. For example, one may use a fused mixture of iron oxide with about one percent of the oxide of potassium. This mixture itself will give off some ions, but more are emitted if the material is reduced, by hydrogen, so that a part or all of the iron oxide is converted into metallic iron and possibly a part of the potassium oxide into metallic potassium. In a similar way, a mixture of iron with the comparatively rare element, caesium, will give a stream of caesium ions.

To see the possible importance of this in radio we need only to remember that the operation of the ordinary amplifier and detector tubes depends on a stream of electrons given off by the filament. Suppose we make a radio tube which contains, instead of the ordinary tungsten or thoriated-tungsten filament, a strip or wire of the new material discovered by Dr. Kunsman. This new tube will operate with *ions,* just as our present tubes do with *electrons.*

The most obvious new feature thus introduced is that the tube will be electrically reversed. The plate will be negative; the filament will be positive. If a C battery is used, its polarity must be the reverse of present practice. The particles of electricity inside the tube will still move from filament to plate, as now. But these particles will be positive, not negative. The passage of current through the tube will be reversed.

This reversal is not likely to be, in itself, of any great importance. What is likely to be important is that the ions, which now replace electrons as the tube-current carriers, are vastly heavier than electrons. A potassium ion, for example, weighs over 60,000 times as much as does a single electron. This means that the stream of ions from filament to plate will have a considerable inertia. It will not be deflected so easily or so quickly as is the stream of electrons in an ordinary tube. Also, space charge relations will be quite different; the internal impedance characteristics of the tube will be altered; there will be entirely different responses of the tube to the frequency of the voltage impressed on the grid.

For some purposes, of course, these changes will mean no improvement. There are times when we wish the current-carrying particles in a tube to have as little mass and as low an inertia as possible. Then what we need is an

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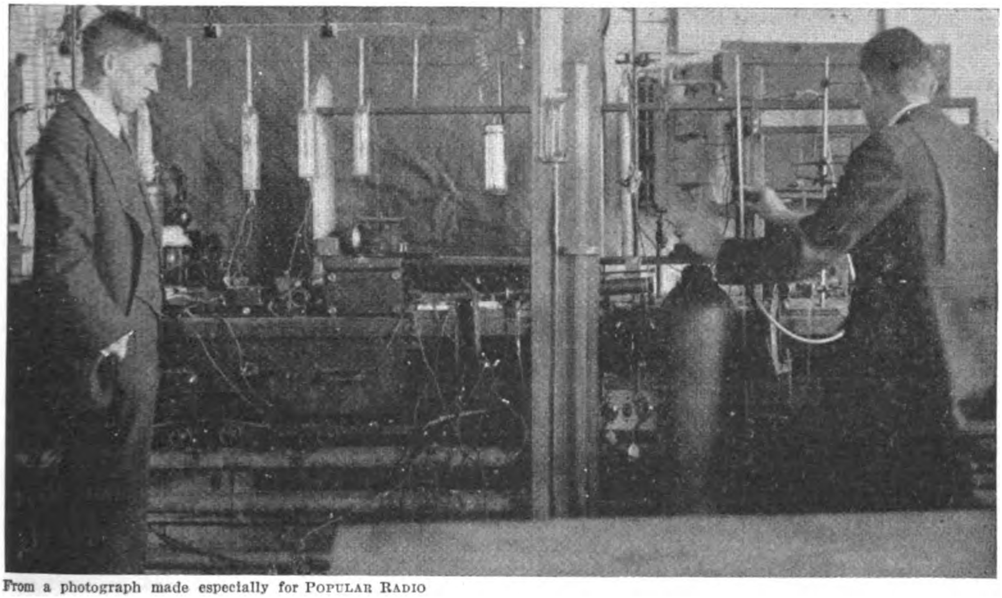
[*] "A New Source of Positive Ions," by C. H. Kunsman, *Science* (Lancaster, Penna.), vol. 62, pages 269-270 (September 18, 1925).

[†] The modern theories of the structure of the atom have been described in numerous papers in POPULAR RADIO during 1924 and 1925.



From a photograph made especially for POPULAR RADIO

TESTING THE NEW ION-EMITTING MATERIAL

This apparatus, set up in the Fixed-Nitrogen Research Laboratory, at Washington, is used by Dr. Kunsman (at the left) and his assistant, Mr. R. A. Nelson, to determine the ionic emission and other properties of the new material. Several special vacuum tubes are connected to the glass manifold in the center. The vacuum pumps are behind Dr. Kunsman and the electric meters are in front of Mr. Nelson. POPULAR RADIO *is indebted to Dr. F. G. Cottrell, Director of the Laboratory, for permission to publish this photograph and those on pages 166 and 168.*

electron tube, like those now in use. But there are other purposes for which some electric inertia in the tube is advantageous. When all of the characteristics of an ionic tube have been worked out we shall discover, probably, that there are numerous radio uses to which the new ion-emitting material of Dr. Kunsman may be put. It will be very interesting, for example, to try this material, and the reversed tubes made with it, for audio-frequency amplification under the large loads which some of the modern loudspeakers and public address systems are coming to require.

Rolling Hoops Through the Ether

JUST two years ago POPULAR RADIO predicted that the newer quantum theories of the nature of light would be applied some day to radio waves as well and would profoundly modify our ideas of the nature of radio transmission.* The first part of this prediction has been fulfilled. A possible application of the quantum theory to radio waves has been suggested by no less an authority than Sir Oliver Lodge; the same scientist, as it happens, whose work we were reviewing back in 1924 when we made the prediction just mentioned.

In a recent address, delivered as President of the Radio Society of Great Britain, Sir Oliver suggests a new structure for the ether waves of radio, a structure which brings them in line with modern ideas of the nature of light. This structure may be visualized, essentially, as a vast series of rounded rings of force, flying outward from an energized antenna as though a boy were throwing millions of hoops from the top of a tower.† Sir Oliver, as is his admirable custom, makes this suggestion tentatively and with modest disclaimers of originality. Nevertheless, a substantial element of originality is there and the suggestion is likely to play a significant part in the development of the newer theories of light and other radiations, as well as in the theories of radio.

Modern theories of ether waves are characterized, readers of this Department will remember, by great uncertainty and confusion. On one side, there are many facts about light and X rays and radio waves which indicate that all such radiations consist of waves in the ether, not unlike the waves on the sea. This is the "undulatory" of spreading-wave theory. On the other side, there are many facts, notably the facts of photo-electricity, which refuse to fit into the wave theory at all. They indicate, on the contrary, that light is composed of innumerable minute particles or "bundles" of energy, each flying through space as though it were a bullet shot out from the luminous source like lead slugs from a machine gun. This is the quantum theory. The light bullets are called quanta.[*]

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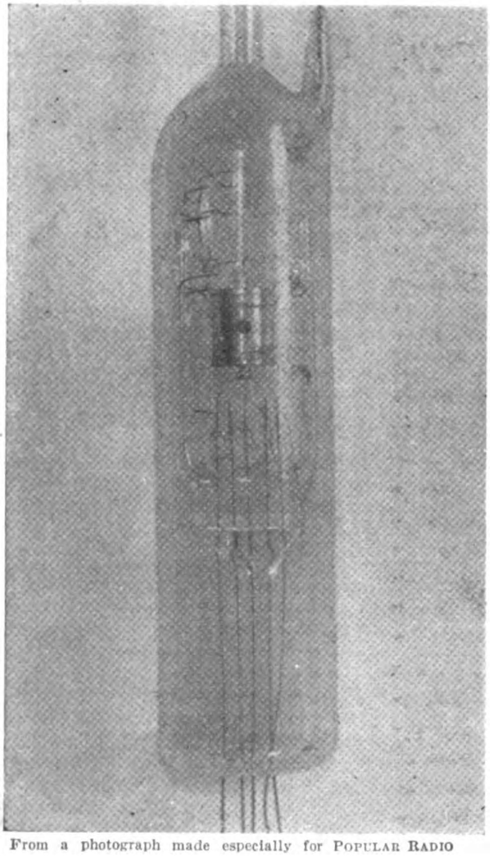
*"Are Ether Waves Composed of Minute Particles?", POPULAR RADIO for February, 1924, page 209.

†"The Mechanism of Radiation," by Sir Oliver Lodge. Presidential Address before the Radio Society of Great Britain, delivered September 23, 1925. Printed in *Experimental Wireless and the Wireless Engineer* (London), vol. 2, pages 884-888 (November, 1925).

The conflict between these two theories has developed mainly in the field of light waves, the wavelengths of which are to be measured in billionths of a meter instead of the meters which we use for radio waves. Radio waves have been left out of account, doubtless because the simple wave theory fits well enough the phenomena ordinarily encountered in radio. No puzzling quantum phenomena, like those of photo-electricity, have been met with, as yet, in the radio field.

However, there can be small question that all ether waves are essentially alike. If there are small quanta in light rays and if the quantum theory applies to them (instead of the wave theory) we must expect to find quanta in radio waves also. We must prepare to abandon our simple, present-day theory of a spreading ripple in the ether, moving out uniformly from the transmitting antenna. In his Radio Society address Sir Oliver sets out to visualize, so far as may be possible, something of what this radio-wave quantum may be like.



From a photograph made especially for POPULAR RADIO

HOW AN IONIC TUBE IS BUILT

These tubes are not constructed for radio use, but merely to test the properties of the ion-emitting material and the effects of the emitted ions on gas mixtures inside the tube. The ion-emitting source is inside the metal cylinder at the center.

It is reasonably certain, of course, that neither the quantum theory nor the wave theory is completely wrong nor completely right. The true theory of ether waves must embody and explain both of them. It must be consistent with the facts that indicate the presence of waves as well as with the facts that indicate the bullet-like quanta. Last year, Sir J. J. Thompson, familiar to readers of POPULAR RADIO through his researches on electrons and atoms,[*] made such a harmonizing suggestion. He suggested that *both* waves and quanta were sent out simultaneously from a radiating body. Or, to phrase the matter differently, he suggested that the radiation which went out had both the properties of a wave and the properties of a flying particle.[†]

Sir Oliver Lodge takes this as his starting point. He points out, also, that it is impossible to imagine that the ultimate "particle" of radiation can be anything of the nature of a solid particle, even an atom or an electron. The thing that flies is no particle in that sense, but is, he believes, some disturbance in the ether. The problem which confronts us is the decision between a single, discrete disturbance in the ether—as, for example, a vortex ring like a smoke ring in air—and a continuing, alternating disturbance such as would constitute a true wave.

The solution suggested is based on the idea of loops or rings of force. Everyone is familiar with the lines of force looped up and down the diagram of a radiating antenna. These lines are supposed to represent the electromagnetic forces existing when the antenna is energized. "The question arises," says Sir Oliver, "whether these lines of force are physical realities or only geometrical abstractions. Most of us thought they were abstractions. Faraday seems sometimes to have had an instinct that they might be real."

"If the lines of force are realities," Sir Oliver continues, "the loops which are thrown off by a transmitting aerial are not mere pictorial representations or diagrammatical illustrations but are a bundle of physical realities, each loop with an independent existence, *each loop constituting a quantum.*" * * * "What I suggest is that *the quantum arises from the reality of the lines of force.*"

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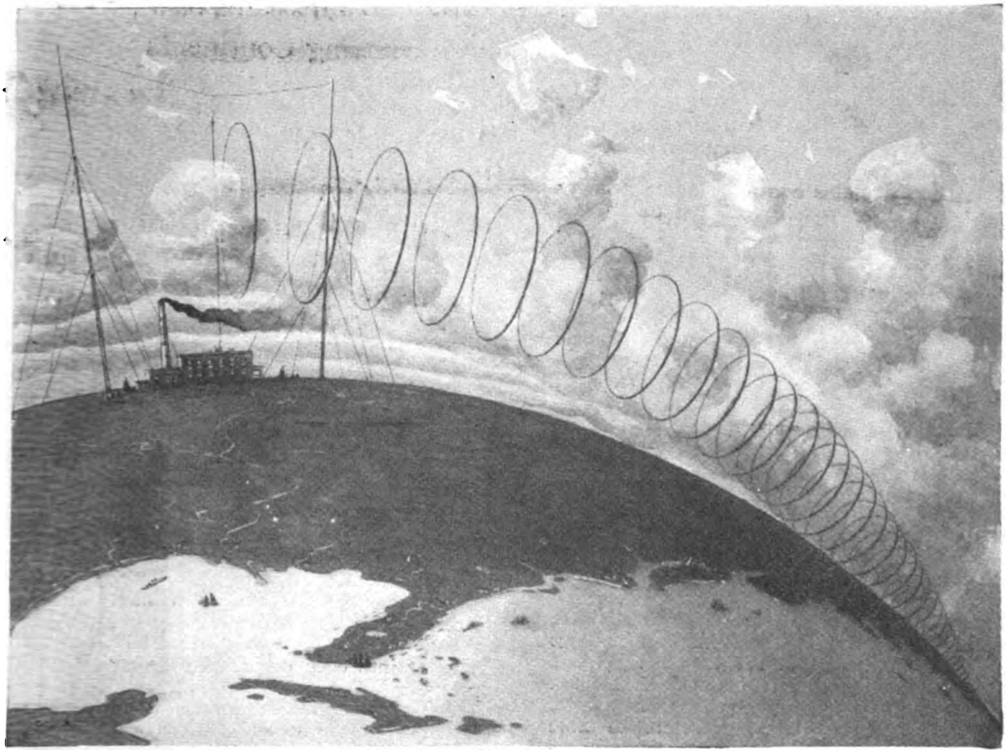
[*] For an account of the differences between the wave theory and the quantum theory, with references to some of the literature, see: "New Theories of Ether Waves," in this Department of POPULAR RADIO for August, 1925, pages 168-171. On photo-electricity see: "Radio's Newest Instrument—The Photo-electric Cell." POPULAR RADIO for November, 1925, pages 397-404.

[*] See, for example, "New Theories of How the Atom is Put Together," by Sir Joseph John Thompson, POPULAR RADIO for September, 1923, vol. 4, pages 179-186.

[†] The suggestion, made originally in an address at Cambridge, England, was printed in *The Philosophical Magazine* (London), vol. 48, pages 737-746 (October, 1924). It was amplified, in more popular form, in a lecture at Guy's Hospital, London, on May 7, 1925, and has been published in a pamphlet, "The Structure of Light," issued by the Cambridge University Press, Cambridge, England, 1925.



From a photograph made for Popular Radio by Arthur T. Merrick

SIR OLIVER LODGE'S SUGGESTION OF ETHERIC HOOPS

This diagram, greatly simplified, gives an idea of the suggestion that ether waves consist of loops of force, flying off through space from an energized antenna. In reality, the loops of force are thought of as being numbered by billions each second, and as flying off in all directions and with all possible inclinations of the plane of the loop. The loops move with the speed of light. Light rays are supposed to consist of similar loops much smaller in their diameter.

For a radio antenna, the quantum-loop thus emitted is conceived as large but feeble; something, Sir Oliver said, "of the nature of waves in some respects, though apparently vortex rings, but vortex rings with a wavelength equal to their own circumference." For an ordinary broadcasting wave, then, the circumference of the quantum-loop would be of the order of three hundred meters and its diameter a little less than one third as much. A vast number of these separate rings or loops of energy is sent out from each antenna; one ring, as Sir Oliver appears to assume, for each electron which travels up and down the antenna wire. Since the rings are of relatively large diameter, a large absorber (the receiving antenna) is needed to pick up their energy and to make them physically perceptible.

In the case of light, the rings of energy are assumed to be produced by the fall of an electron from one position inside an atom to another position. The displacement is minute and the diameter of the quantum-ring sent out is equally so. Accordingly the absorbing unit may be small. A single atom may pick up a quantum of light; it will not absorb the much larger quantum-rings of radio.

Sir Oliver does not pretend to have completed the mathematical application of this hoop-of-energy idea to all the facts of physics or to have solved all of the difficulties in making such applications. He offers it merely as a suggestion. As such, it is probably the most reasonable and comprehensible yet made toward the solving of the great riddle of radiation. And not the least interesting thing about it, to the radio engineer, is that it has been attained and developed by a study of our own pet radio waves instead of by the study of the physicist's usual material among the "shorter" waves—Sir Oliver would say the smaller hoops—which constitute X rays and light.

Static from Drifting Snow

It has long been known to the physicists that fine dust or fog, suspended in air, is likely to become electrified. That steam clouds from locomotives or from factory chimneys can also acquire an electrification and may become the source of local interference is a suggestion already noted in this Department.

Now comes a German scientist, Dr. A. Stäger, with careful experiments indicating that loose snow may be electrified with ease; experiments which point to drifting snow in cold weather as a very probable site of electrical discharges which may be quite perceptible in nearby radio receivers.*

Dr. Stäger finds that when fine powders are blown about by air currents they invariably become electrified. Snow swept along by a gale in the Swiss mountains was found to be strongly charged. It is concluded that the electrification thus developed in snow clouds or in clouds of ice crystals makes an important contribution to the electricity of certain varieties of thunderstorms. One may draw, quite obviously, the further conclusion that when snow is blown along by the wind during the wintry nights of this time of the year, the electrification developed may become a veritable static broadcaster, although presumably with no great intensity.†

That actual falls of snow are frequently accompanied by troublesome static is an observation made by many radio listeners. Two winters ago, in response to a note to this effect in POPULAR RADIO, many readers wrote us confirming it from their own experience. And, if Dr. Stäger's results are accepted, we must ascribe similar static-creating properties to loose snow blown along the ground by wind.

Listeners who live in localities where loose snow is frequently blown about can perhaps obtain data confirming or refuting Dr. Stäger's ideas by noticing whether or not the amount of static is greater when much loose snow is adrift. It will be interesting, too, to note whether this static is of the "whispering" variety or of some other kind.

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*"Experimental Investigations into Contact Electrification by Dust and Cloud-Forming Powdered Substances, and Especially of Snow as a Factor Producing Storms" (in German), by A. Stäger. *Annalen der Physik* (Leipzig), vol. 76, pages 49-70 (January, 1925). A later account appears in the same magazine for August, 1925.

†"Radio Interference From Clouds of Steam," POPULAR RADIO for July, 1925, page 87. Additional observations, confirming those recounted in this note, have been published by P. L. Mercanton, in a letter printed in *Nature* (London), vol. 115, pages 874-875 (June 6, 1925).

Radio to Test Theory of Drifting Continents

THAT the continents of the earth, Africa, Eurasia and the two Americas, are not fixed in their positions, but drift slowly across the earth's surface, is the revolutionary theory proposed fourteen years ago by the distinguished German geologist, Professor Alfred Wegener. Since then, and especially since the end of the war made international scientific cooperation again possible, the world's geological experts have been devoting an increasing amount of attention to the idea. It was under active discussion at the meeting of the British Association for the Advancement of Science, at Southampton, last summer, upon which occasion Professor J. W. Gregory, head of the Department of Geology at the University of Glasgow, made the suggestion that the matter be put to the test by means of radio.*

Professor Wegener's idea is that the rocks of the earth are not uniformly rigid, but that there exists a layer of semi-viscous rock, many miles down below the surface, on which layer the continents float, much as icebergs float in the sea. The land mass of the two Americas was once in contact, he thinks, with the western edge of Europe and Africa. Anyone can note on the map that the two continental margins seem to fit into each other, like the parts of a picture-puzzle. During the millions of years of past geologic time America has drifted, Professor Wegener believes, to the west. It is drifting still. Evidence is produced to indicate that early determinations of the longitude of Greenland show a more easterly position than the present one. According to Professor Wegener, this westward motion of Greenland may have been as much as thirty meters a year.

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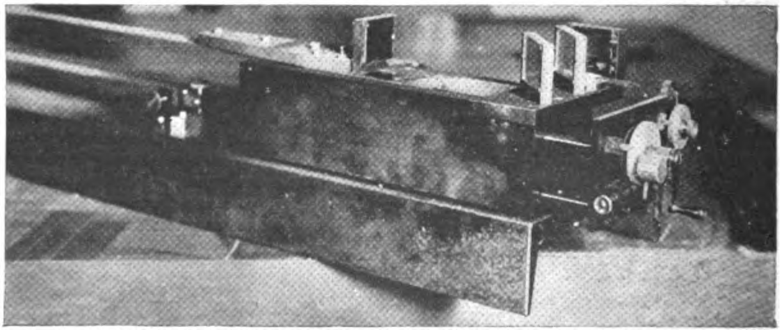
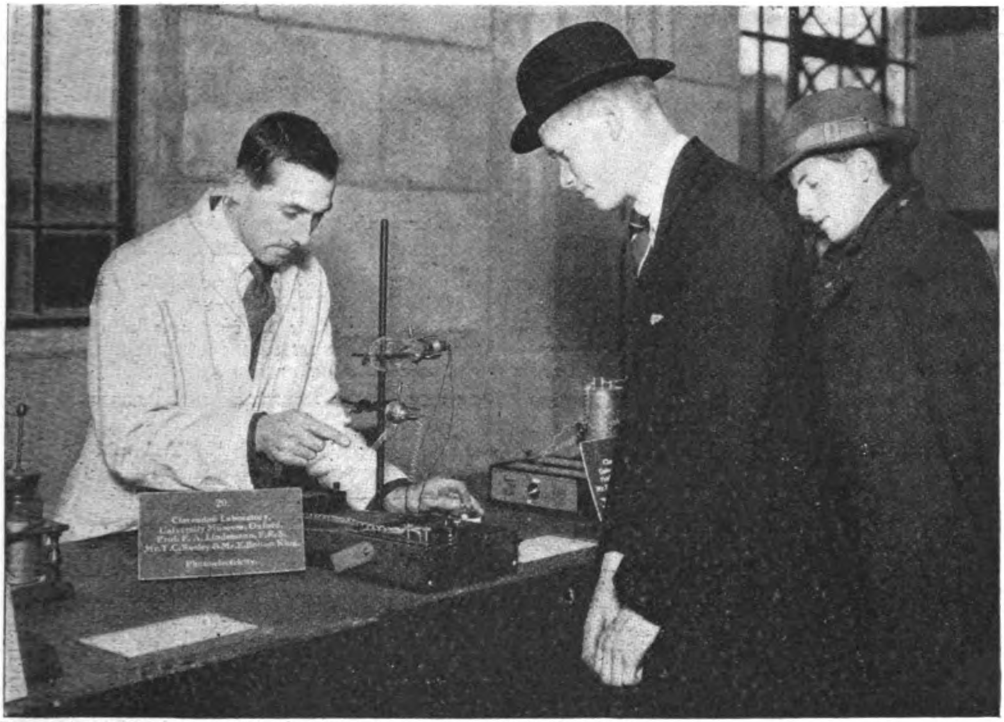
* Professor Gregory's suggestion was published in a newspaper notice released by Science Service, Washington, D. C., on September 2, 1925, and printed in *Science* (Lancaster, Penna.), vol. 62, number 1602, page x of advertising section (September 11, 1925). We are indebted to Professor Gregory for kindly supplying some additional details.



Robert H. Moulton, Chicago

PROFESSOR MICHELSON'S FAMOUS INTERFEROMETER

With this instrument, devised by himself, Professor A. A. Michelson, the distinguished physicist of the University of Chicago, has investigated a series of light-wave phenomena which indicate the wave theory of ether waves, instead of the quantum theory. Sir Oliver Lodge's new "flying loop" theory is an attempt to reconcile these two opposing theories of radiation.



From a photograph made especially for POPULAR RADIO by Campbell-Gray, London

PHENOMENA WHICH THE WAVE THEORY WILL NOT EXPLAIN

As pointed out on a previous page, the phenomena of photo-electricity have never been explained satisfactorily by the wave theory of light. The quantum theory does explain them. This exhibit, set up by the physicists of Oxford University at the Wembley Exhibition, demonstrates the emission of electrons from metallic caesium, contained in the lower bulb, under the influence of light rays from the upper, electric-light bulb.

This amount is ample, Professor Gregory pointed out at Southampton, to be detected within a very few years by means of radio determinations of longitude. The radio time signals sent out from the greater radio telegraph stations constitute, as every radio fan knows, the most precise method of determining longitude yet devised. This radio time is compared with local time, as read from the stars. If the point of observation drifts, by even so little as thirty meters a year, this drift is soon evident as an increased difference in time. It is proposed to apply this suggestion to the determination of the motion, if any, of Greenland by making radio longitude determinations there for a series of years until the truth or falsity of the Wegener theory becomes apparent.*

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* The Wegener theory is outlined in detail and the evidence for it is collected in "The Origin of Continents and Oceans," by Alfred Wegener, translated by J. G. A. Skerl, 205 pages, E. P. Dutton and Company, New York, 1924.

The Tilting of Radio Waves

In this department for September, 1925, were described the important experiments of Dr. Smith-Rose and Mr. Barfield on the inclination of the electrostatic and electromagnetic fields at the front of a radio wave arriving from a distant station. It was expected that the wave-fronts might be found to be tilted downward somewhat when they were arriving after a passage through the upper atmosphere—through the so-called Heaviside Layer. No determinable effect of this kind was discovered, at least one of the obstacles being the fact that the conductivity of the soil in England was high enough to affect the inclinations of the electric and magnetic fields of the wave.

Dr. Smith-Rose and Mr. Barfield have now published an account of this work especially from the viewpoint of the radio engineer.* The conclusions are unchanged, but radio experts especially interested in the subject or intending to repeat the experiments will do well to consult the experimental details and the mathematical theory outlined in the newer and more complete publication.

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*"Some Measurements on Wireless Wave Fronts," by R. L. Smith-Rose and R. H. Barfield. *Experimental Wireless* (London), vol. 2, pages 737-749 (September, 1925).

WHAT READERS ASK

CONDUCTED BY HUGH S. KNOWLES

IN *justice to our regular subscribers a nominal fee of fifty cents per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' inquiries should be limited to one question or one subject.*

A Simple Way to Control Regeneration

QUESTION: I have an eight-tube superheterodyne of standard construction using a separate oscillator. I want to experiment with the use of regeneration in the loop circuit. Is there any simple method of controlling the amount of regeneration secured without having to use a separate coil, tickler or anything of that type?

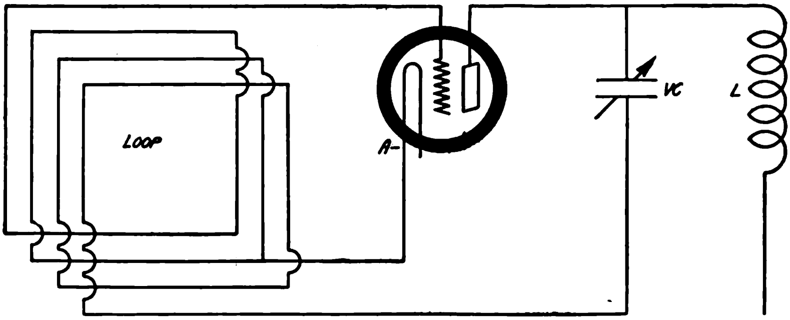
N. FRAZER

ANSWER: A simple way of controlling regeneration is shown in Figure 1. A loop with a mid-tap should be used. The outside turn, if the loop is of the pancake type, should be connected to the grid and the mid-tap to the negative filament lead. The loop tuning condenser which is incorporated in the set (not shown in the diagram) is connected from the grid to the filament. A small variable condenser of from .00005 to .0001 should be connected as shown at VC. The coil L is the output coil or primary of the first intermediate-frequency transformer. If VC is one of the "midget" condensers now available it can be mounted on the front of the panel. If tuning is too difficult when using it tune the set to a low wavelength and adjust VC just below the oscillating point and leave it fixed.

This arrangement should be used only when a separate oscillator is used and the amount of energy from the oscillator can be controlled. In circuits of the autodyne type tuning is considerably more complicated and this arrangement is not recommended.

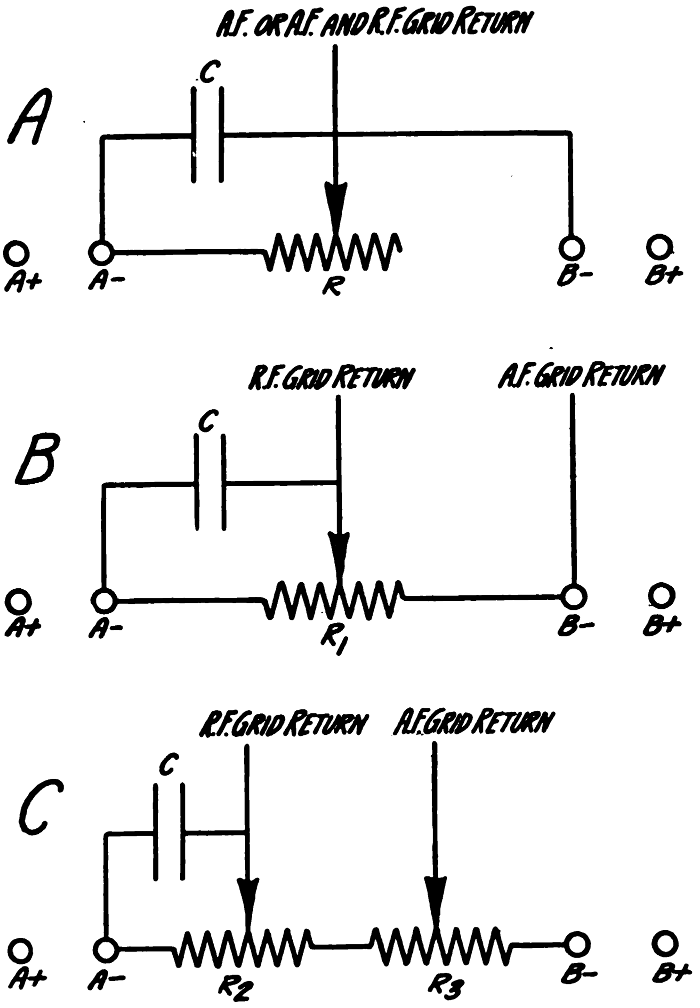
How to Use a Grid Bias

QUESTION: I want to build a five-tube receiver of the neutralized radio-frequency type; it will employ two stages of radio-frequency amplification and two of transformer-coupled audio-frequency amplification. Is there any way of get-



THE CONTROL OF REGENERATION IN THE LOOP CIRCUIT

FIGURE 1: *This is a skeleton diagram showing the connection of the small variable condenser which controls the oscillations. The loop tuning condenser which is mentioned in the text, is not shown here.*



THREE WAYS TO SECURE A GRID BIAS WITHOUT A "C" BATTERY

Figure 2: *These three diagrams, A, B, and C, illustrate the methods of obtaining a grid bias which have been described. Other methods which make use of the same principle will readily suggest themselves to the experimenter.*

ting the proper grid bias without using a "C" battery? Should I use a bias on both the radio and audio stages?

Harvey Smith

Answer: The bias normally necessary on a receiver of this type may easily be obtained by any of the three methods shown in Figure 2. If the radio-frequency stages are "neutralized" or "balanced" to prevent oscillation, it is advisable to use a negative bias on the first two tubes. The ampere-hour delivery of a "B" battery rises rapidly with decrease in current drain and a negative bias on these tubes will considerably increase the "B" battery life.

If the set is carefully designed and the coils set so there is negligible inductive feed back it will be fairly easy to neutralize the amplifier even with a negative grid bias. In this case the method shown in Figure 2 A may be used. This gives the same bias to both the radio and audio-frequency tubes. R should be a 400 ohm potentiometer used as a variable resistance; C should be a .002 to .006 mfd. condenser to by-pass the radio-frequency currents. It should be connected from the end of the secondary of the radio-frequency transformers to the negative filament lead. Make the connections as short as possible.

The bias which is secured can be readily determined from Ohm's law

$$E = RI$$

where E is the bias, R the amount of resistance used in the potentiometer (*i.e.* the fraction actually used, not 400 ohms) and I, the

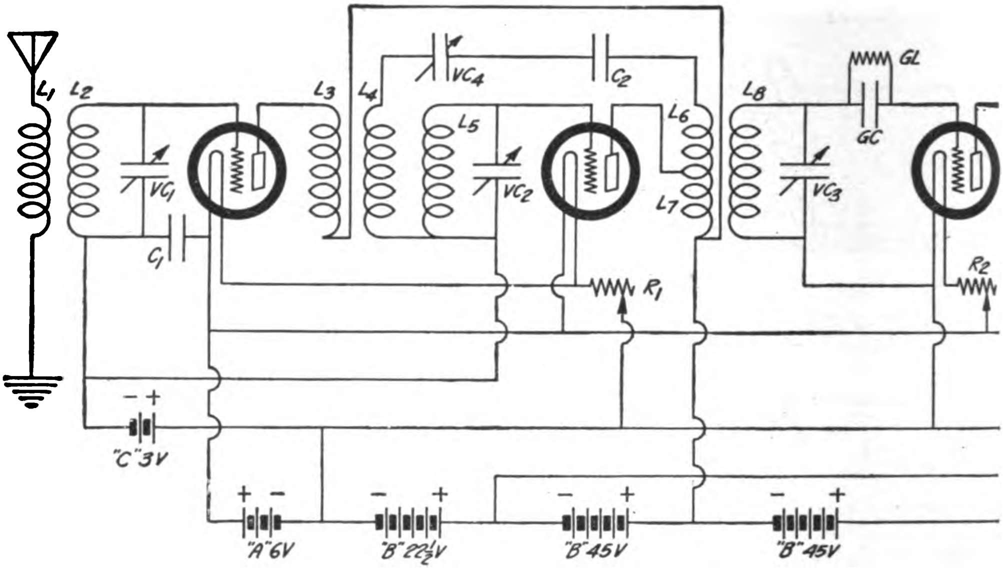


plate current or "B" battery drain of the whole set.

Three or more volts bias should be used on the audio-frequency amplifier. If the radio-frequency stages can not be stabilized with this much bias either the method shown in Figure 2, B or C may be used. The method shown in B will give a fixed bias for the audio stages with a fixed plate current and a variable bias on the radio-frequency stages. The latter variable is an advantage, as it permits adjustment just below the oscillating point for maximum sensitivity.

The bias on the audio stages will depend on the "B" battery current which in turn will vary with the grid bias used on all of the tubes. With this bias properly adjusted the normal current for a set of this type will be about 10 to 15 milliamperes. The equation previously given shows that if a 200 ohm potentiometer is used at R, the bias will vary between 2 and 3 volts, which is slightly low. A 300 ohm potentiometer will give a bias of from 3 to 4.5 volts and a 400 ohm potentiometer from 4 to 6 volts on the audio stages. In each case the grid voltage can, of course, be reduced to O by decreasing the amount of resistance between the slider arm and the negative A to O.

The arrangement shown in Figure 2 C permits variation of the bias applied to both the radio and audio-frequency amplifying tubes. The radio-frequency bias may be adjusted from O to 2 or 3 volts with a 200 ohm potentiometer at R_2 depending on the plate current, and the audio bias regulated from 2 or 3 volts to 4 or 6 with the same size potentiometer at R_3. Radio-frequency by-passing condensers should be used as shown. The impedance across the biasing resistance is very small compared to that of the whole output circuit and there will be negligible grid voltage variation due to the alternating plate current variations.

The Parts You Need for a "Nameless" Receiver

QUESTION: I have a set of coils for a "Nameless" set and would like to build one. I find that the circuits available vary somewhat, and I should like to have the proper circuit and a list of the other parts necessary with their values.

C. HOOPES

ANSWER: The circuit you request is given in Figure 3. You will need the following parts in assembling it:

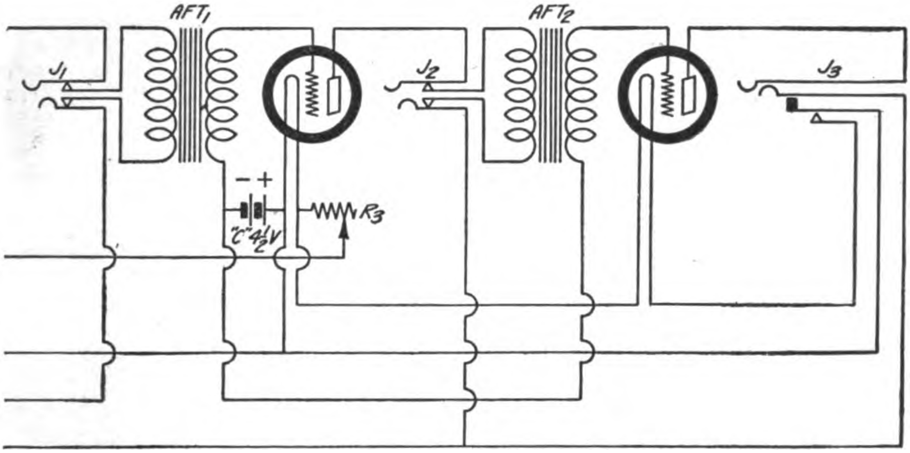
L1, L2, L3, L4, L5, L6, L7 and L8 are a set of Bremer-Tully "Nameless" circuit coils;
VC1, VC2 and VC3—Variable condensers, .00025 mfd.;
C1 and C2—Fixed condensers, .001 mfd.;
R1 and R3—Rheostats, 20 ohm;
R2—Rheostat, 6 ohm;
GC—Grid condenser, .00025 mfd.;
GL—Grid-leak, 2 megohm;
J1 and J2—Jacks, double circuit;
J3—Jack, single circuit, filament control type;
AFT1—Audio-frequency transformer, first stage type;
AFT2—Audio-frequency transformer, second stage type.

The "A" and "B" batteries should have the values noted.

R1 controls the filament current of the two radio-frequency tubes, R2 the current of the detector tube and R3 that of the two audio-frequency amplifier tubes. The filament of the last tube is controlled automatically by the jack, but if the telephone plug is inserted in the first jack the rheostat has to be readjusted. This trouble can be eliminated by using an automatic filament control cartridge in series with the fila-

THE HOOK-UP OF THE "NAMELESS" RECEIVER

Figure 3: *The proper wiring diagram of the "Nameless" Receiver using "C" batteries in both the radio and audio-frequency stages is shown here.*



ment of the last tube after disconnecting it from the rheostat R3.

The condenser VC4 should be adjusted just below the oscillating point when the set is tuned to a low wavelength. The condenser C2 prevents the "B" battery being short-circuited through VC4.

The value of GL will vary slightly with different tubes and several values should be tried.

If a hard tube of the 201-a type instead of a UV-200 is used for a detector the grid return from the detector tube should be connected to the A plus. The rheostat R2 should then be a 30 ohm one.

"C" Battery with Resistance Amplifier

Question: I have a set using two stages of radio-frequency amplification, detector, one transformer and two resistance stages of audio-frequency amplification The transformer stage has a "C" battery giving it 3 volts (negative), but the resistance stages have none. I would like to know whether or not the resistance stages should be connected to use this negative bias?

Frank McGear

Answer: Less "C" negative bias can be used in a resistance-coupled amplifier than in a transformer-coupled amplifier. This is due to the fact that the combination of the blocking or grid condenser and leak gives a very small negative bias. Where only a small bias is wanted this system of obtaining it is satisfactory. This is sufficient for the first stage if a 201-a type tube is used, both because the bias needed is slight and the plate voltage is fairly low. Although 135 volts is generally used on the plate circuit the drop through the coupling resistance generally brings this down to from 25 to 50 volts. In the last stage practically the full 135 volts is applied to the plate due to the low resistance of the loudspeaker. Unless special provision has been made for either using a lower plate voltage or introducing a resistance in this circuit it will be advisable to use about 4.5 to 7.5 volts negative bias on the last tube. This would require a high resistance leak which would permit the accumulation of a high charge on the condenser. The grid cannot become more negative than necessary to reduce the grid current to zero by this method. This has the disadvantage of giving a high grid swing when a loud signal comes in and if the coupling condenser is large there is some time lag before the condenser can fully discharge and reach the point of no signal operation. By connecting the leak to the C (–) lead that you now have you can secure the proper bias with a lower resistance leak. (A separate "C" battery can be used by connecting the plus C to the A minus and the C minus to the leak.) The leak should have a value of approximately .1 megohm (100,000 ohms) as a lower value materially reduces the amplification. The reason for this is apparent when it is remembered that this leak is in shunt to the input circuit of the tube and will therefore lower the voltage applied to the grid of the tube. A more complete discussion of this subject appears on page 112 of this issue.

¶ *The article, "How to Build and Operate a Low-power Transmitter," originally scheduled for this issue, will appear in* Popular Radio *for April.*

Kadel & Herbert

BROADCAST LISTENERS ATTEND A CEREMONY BY RADIO

When Bishop Manning laid the cornerstone of the nave of the Cathedral of St. John the Divine in New York, the occasion was attended—aurally—by those within reception range of station WEAF. The broadcasting of historic events is vastly extending public interest in the news of the world.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

Eight Ideas for Solving the Copyright Problem

A FEW months back we had a little sympathy with the demands of the American Society of Composers and Authors and their efforts to make the broadcasters pay a reasonable fee for the right to use copyrighted work. Subsequent action on the part of the composers, however, has caused us to pitch our tent in the camp of the National Association of Broadcasters and the appalling political power of this department is now squarely behind the movement to free broadcasting from a threat aimed at its very existence. This sudden change in attitude was brought about by the unreasonable fees asked by the composers, fees that show no tolerance, no mercy and anything but a desire to contribute to the most civilizing art that has appeared in the whole range of human history. Broadcasting paralyzes one's mental faculties with its possibilities and yet a peanut-minded coterie of composers would aim an arrow at its very solar plexis or what it thinks to be its solar plexis. It was the spirit of this threat rather than its possible consequences that caused us to dispatch the following wire to the chairman of the Broadcasters committee during its November meeting in Washington:

"It is evident that the Society of Authors, Composers and Publishers is made up of unreasonable and highly overrated writers of the Irving Berlin school of bunk music. They write ditties on their cuffs in Keen's Chop House and expect the American public to pay millions for them. Fortunately broadcasters have been victimized only to the extent that they highly overestimate the importance of the Society of Compromisers, Augers and Penalizers.

"Why does not the National Association of Broadcasters take advantage of its own tremendous power for publicity and banish once and for all time this blustering menace to the radio art? Here is a suggested plan:

"1. Let the National Association of Broadcasters appoint Music Finding and Publishing Committee with the slogan 'More Music From America.'

"2. This committee, through the voice of nearly three hundred broadcasting stations, to ask every American musician to submit his themes for music and words to a central office. The Society of Authors controls only 400 composers. We have 15,000 in America to say nothing of undiscovered talent.

"3. Guarantee the writer of every new song suitable for broadcasting $1,500, which means that every broadcaster in the United States would pay $5.00 for the right to perpetually broadcast a new number.

"4. Broadcasters to organize friendly groups of publishers not members of the Society of Composers. These publishers to receive sole right to publish songs found and popularized by the broadcasters. Publishers would pay authors of song standard royalty. This in addition to the original payment by the broadcasters of $1,500.

"5. On a 500-song-a-year basis, this plan would cost each broadcaster only $2,500 yearly for the use of the latest songs.

"6 Permit broadcasters to sell songs by mail and to announce this on the air.

"7. Broadcasting is the most powerful publicity agency in the world today. It can popularize a song over night. Every song hit is ¼ song and ¾ plugging. Radio can make more song hits in one month than the Society of Composers has made in its entire career.

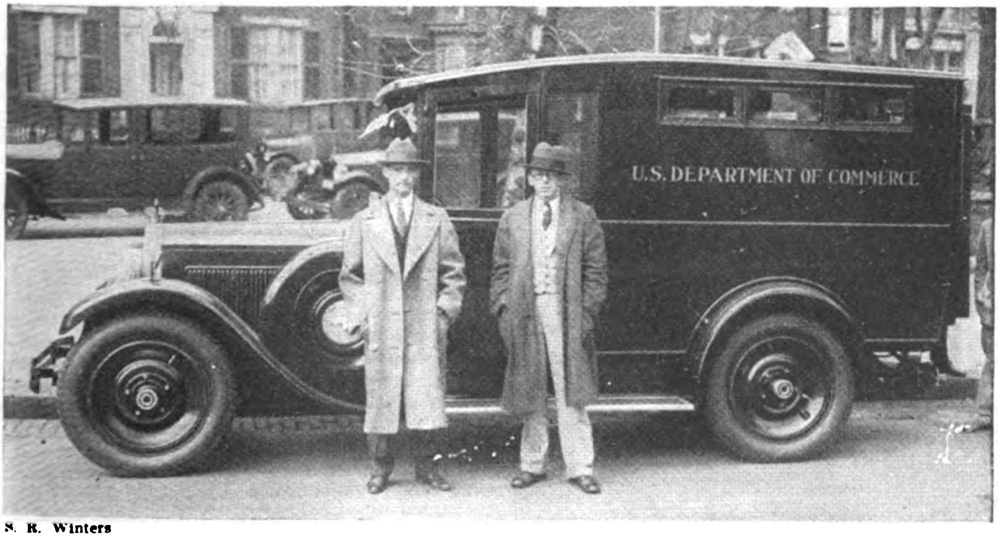
"8. Broadcasters should completely and severally boycott all producers of music that are hostile to radio. The offensive and the initiative should be taken by the National Association of Broadcasters and not by the Society of Composers, Authors and Publishers."

* * *

Another Good Word for a Broadcast Act

THE young man who builds up and measures out the Eveready programs may be a novitiate in the entertainment business, but he has turned out to be an imaginative broadcasting experimenter of no mean ability. For over a year now, he has been providing this department, week in and week out, with a program that is always refreshingly new in thought and in execution. Often these new radio acts are so new that they squeak a little if you put your ear right up close to the horn but they never squeak to the point of hurting. That is something that you cannot say about the new thrusts that have been made by some of our more widely recognized impresarios.. The Eveready Hour is rarely dull and is ofen magnificent.

Back in November, Edgar White Burrill read the sombre lines of "Evangeline" with a warm and sympathetic musical accompaniment



S. R. Winters

A RADIO DETECTIVE ON WHEELS

By means of this automobile, which is fitted out with wavemeters and directional devices, radio supervisors of the Department of Commerce track down disturbers of the listener-in's peace. Violet-ray and X-ray machines (such as are used in doctors' and dentists' offices), leaking power lines, electrically-operated oil-bearing furnaces and sources of interference are located and remedied. Broadcasting stations that venture off their assigned wavelengths are warned to return to their own part of the wavelength band. The area covered by New York, Pennsylvania, Ohio, West Virginia and Michigan is policed in this way.

in the background. It was, according to our fourth-rate judgment, a splendid piece of work but it began to move ponderously after the first half hour had passed. Unless your heart is especially susceptible to the stabs of sentimental poems, a full hour's recitation of "Evangeline" is a pretty heavy dose. It seems to us, and here again we may show ourselves up as being a *naiveté,* that the dramatic features of the poem could have been read in a bare half hour, leaving out the more irrelevant passages. The presentation of this feature left us with the notion that poetry accompanied with music is good if you know where to stop.

* * *

The WEAF Boys Take to Football

When we reach the ninth page of this review we are usually as limp as a rag. This time we have just enough strength left to register a weak protest against the very un-football-like announcing of the two honor graduates of the A. T. and T. Diplomatic School, the Messrs. Carlin and McNamee. This pair might make excellent observers in a clash between the eleven of the Erasmus and Washington High Schools but they flopped badly while working as a unit on the Cornell-Pennsylvania game. Their deportment was just plain terrible. Mr. Carlin sounded like a man who had just completed a digest of the Spaulding Year Book, after years and years of ignorance of the game.

Pacific & Atlantic

BRINGING IN A PROGRAM WITH A PUSH BUTTON

A row of push buttons supplants the usual condenser dials on the panels of this novel receiver. These buttons are wired to cut in on portions of an inductance coil, so that all that is necessary to tune in on a certain station is to push the button marked with its call letters.

First off, Mr. Carlin tried to be flippant and witty and Mr. Carlin is the easiest person in the world to detect in a flippant and witty mood. Mr. Carlin also muffed the significance of many plays, and, to top it all, he found it necessary constantly to correct himself. He did this as many as three times.

When it was all over, the ingratiating Mr. McNamee bobbed up to the microphone and told the audience that he was glad that he personally would announce the Army-Navy game.

This, of course, put an end to all doubt as to the perfect manner in which the Army-Navy game would be handled.

* * *

Nicknames for Announcers

If there is anything contributing to the barber-shop atmosphere of our more loosely managed radio studios it is the nicknames that many of our publicity-hunting announcers take for themselves. To hear the roll call of America's announcers, you might think it was the scrape football team of the gashouse gang. There is the "Merry Old Chief," the "Solemn Old Judge," "The Hired Hand" and dozens of other cheap pseudonyms. All of this, of course, is a neat part of the plan for bigger and better popularity for the announcers. Somebody it seems (perhaps it was Charlie Chaplin) once told the announcers that when they spoke they were speaking to the "masses" of America and it would be necessary for them to gab in a tongue and in a style that the American masses would understand. With few exceptions, this advice has been carried out to the letter and now there is nothing left for our announcers to do but to talk out of the corner of their mouths and to say "Hully gee" on the least provocation.

* * *

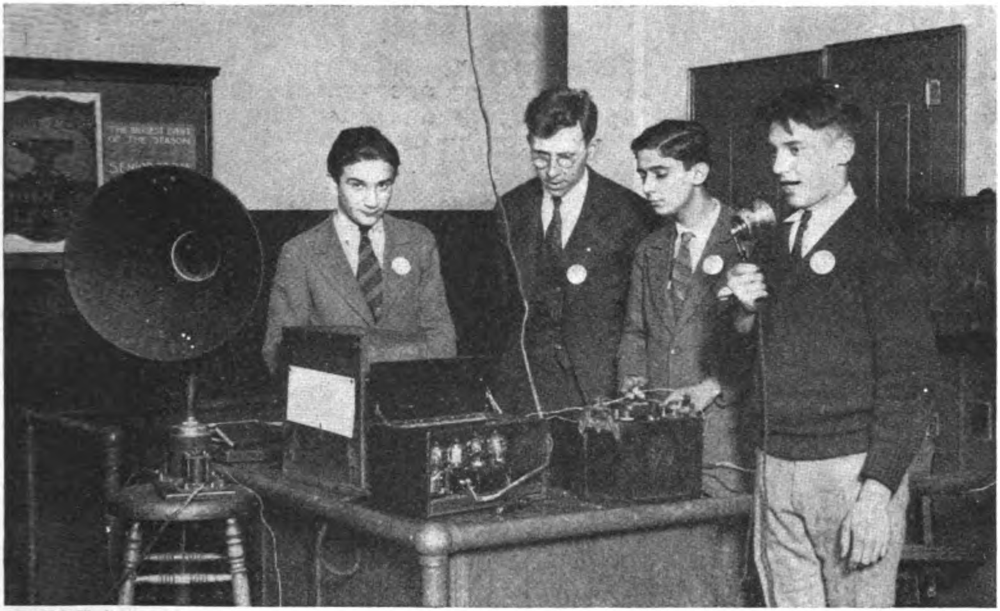
An Apology

Several issues back we waltzed out with a suggestion which has since proven tardy—to be exact we were just about one week late with it. We suggested that broadcasters use the time between studio features to give the late news items of the day. That we figured would be much better than the practice of permitting announcers to fill the interim with impromptu this and that. The records now show that WJZ had begun this sometime before the thought had occurred to us. That, of course, made our big idea a *faux pas* and we hereby bow low and magnificently to the real originator of the innovation.

* * *

Bad Manners That Need Correction

Here is 1926 and we still have broadcasters who eat from their knives and who do all sorts of impolite things. It was only a few Sundays



Kadel & Herbert

THIS AMPLIFIER LEADS THE CHEERING FOR DEAR OLD ALMA MATER

Why strain the vocal chords of the cheering section of the grandstand at an athletic contest when radio apparatus can do the work better? To the Brooklyn Technical High School, New York, belongs the credit of reducing to a science the energies expended in noise-making; a single cheerer, by means of this apparatus, can give a yell that can be heard a mile away.

back that WMCA became impolite to an extent that, to our knowledge, has been unmatched in the annals of the art. WMCA was guilty of more than a tactless error; it was just a plain offense.

This station was scheduled to broadcast its dinner music at seven o'clock; something that had been in the past a staple and satisfying feature coming as it did at the end of a rather uneventful afternoon. You can well imagine that this department developed a somewhat high temperature in the region of the collar bones when, instead of hearing the overture of the orchestra, it was introduced to a gentleman who was selling—guess what? Automobile paint! We were tremendously stirred by this crass breach of form and while at our hottest we had even thought of writing to Mr. Hoover to see if his next conference could not put down a law to thwart the trick of obtaining listeners under false pretenses. On second thought, we decided that mother has only one pair of hands and that she has plenty of naughty broadcasters to take care of without our becoming a tattle-tale.

* * *

A Crestfallen Critic

FULLY understanding the staggering difficulty of finding a radio program scheme that would meet with universal approval and being fully cognizant of our own limitations in the matter, we asked our readers (in the November issue) to help us solve this enigma of the radio business. Up until this time, we had thought that radio listeners had some pretty definite notions about what they wanted and they did not want and that they would, upon the least provocation, show our studio managers how far they were from hitting the popular idea.

Our plan, we regret to announce, has fallen flatter than Aunt Clara's pancakes, and we are quite broken up about it. We did receive a deluge of letters but, instead of proving our point, they showed unmistakably that our studio managers are not so dumb as we had thought they were and that, further, they are giving the great American public a pottage of entertainment with just about the right flavor. Here we have been basing our calculations on a *pate de foi gras* basis when we should have started off with noodle soup. And so we turn away crushed and defeated but way down in this old hulk a tiny voice is saying: "You've got the right idea but the world is cockeyed."

The first prize for the best program received goes to Mrs. Bessie Jones of Glen White, W. Va. We might add that it was Mrs. Jones' letter more than her program that caused us to favor her solution to the problem.

Mr. T. B. Davis, Keyport, N. J., came within a bed-time story of beating out Mrs. Jones. Mr. Davis was doing fine until he put "Children Stories" in between 7:30 and 7:35 o'clock.

The Applause Card Nuisance

We have just about lost our patience with the studios that insist upon asking for mail after each feature, and we are posting a fair warning now. If it continues for another thirty days—let's see, that puts the time limit at February 20—we shall set out on a special murder campaign, and no power in this wide, wide world will stop the carnage. Dark-skinned men in slouch hats with bandanna handkerchiefs about their necks will be stationed outside studio entrances to strike low those who dare to invite listeners-in to write to this or that artist. This is final.

If there is one thing that sends this reviewer into something more than a mild frenzy, it is the invitation to applaud this or that artist (and often much less) by mail. Nor does that mean that we are a savage old ingrate. While we do not raise our hands very high or shout "bravo" while applauding at the theater, we applaud as often and as boisterously as any theatergoer west of Eighth avenue between Fifty-ninth and Thirty-fourth streets. What we object to, and the one and only cause of our special thirty-day murder campaign, is being asked to applaud. In asking you to applaud, an announcer arbitrarily assumes that you have just graduated from 6th Grade Class B and that, further, you are mentally nothing short of a classical specimen of dumb-bell.

Imagine, if you will, the spectacle of Mr. Ziegfeld stepping out on the stage at the New Amsterdam Theater to ask his audience to applaud! Now just a moment there. We knew that you would say that Mr. Ziegfeld pays good big money to his actors and that we have no right to make such a comparison. Well, Smarty, we insist that this has absolutely nothing to do with the case. Nobody insisted that Annabell Tish come to KFI or that Hortense Simpson should bring to a close her three years of vocal lessons with a début from WJZ.

Pacific & Atlantic

THE HEAD RADIO ANNOUNCER

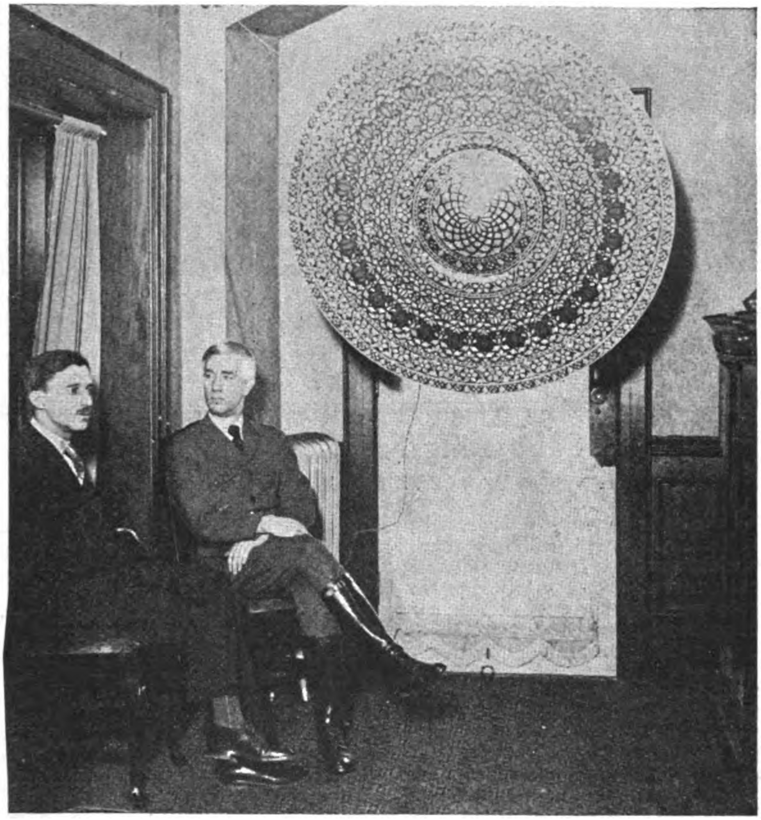
Mr. Arthur F. Edes (known to radio fans as E-F-A, is president of the Radio Announcers of America. He is the program director of station WEEI in Boston.

All of this is by way of combating a growing American tradition that all broadcast performers are, in a measure, a sort of entertainment section of the Salvation Army and that you, ourselves, and your good neighbor Jones, owe each and every artist a nice helpful word of encouragement. You are supposed to carry around with you a line of thought something like this: "Well, the poor devils are doing their best to entertain the great American public, and I guess I at least owe them an applause card." If you don't believe that that is the thought you are supposed to put under your old derby, just listen to the pathos in the voice of the next announcer that asks you to endorse the activities of any performer.

There is just one more angle to this subject, Dear Reader, that we wish to discuss with you before you indulge in the big, airy paragraphs beyond. You have probably heard the nice little boys down at WEAF come to the microphone and tell you in a sort of well-you-know-it-doesn't-make-any-difference-to-us way that the members of the Little Wonder Gas Lighter orchestra would appreciate knowing whether or not their program was good. The Little Wonder boys, no doubt, have an autographed post card (Mr. Antonio Bambirinio, the conductor conspicuously seated in the exact center of the first row) which they will be glad to send to their admirers. It may be that you will be lucky enough to horn in on some of the free samples of baking powder that the big-hearted president of the Hoosick Falls Chemical Company has decided to distribute, or perhaps you can get that cookbook that tells you about muffins without butter and shortening.

The WEAF announcing sorority exhibit some of the most beautiful, hand-carved announcements that have ever been turned loose upon the air of these United States. Nobody but a full-fledged graduate of the A. T. and T. Diplomatic School could issue such carefully tooled invitations. Time and time again we have sat before our loudspeaker and defiantly answered them back with: "Well, you're pretty slick, but you can't fool this sly old weasel."

Now here is some inside dirt. Don't you believe what we said about WEAF not being interested in receiving applause cards. It is rumored that the first thing the big director of broadcasting does when he arrives at the office in the morning is to ask for the number of applause cards received. If the number is not great enough to satisfy the advertiser, the professors of the WEAF Diplomatic and Rhetoric School are given implicit instructions to remain closeted with "the boys" until they can exude an announcement that will make John D. Rockefeller, Sr., write for the catalog of the Pine Valley Oil and Refining Co.



Armstrong Perry

A LOUDSPEAKER THAT MAY SUPPLANT THE DANCE ORCHESTRA

This plaque-like device, which the inventor, Mr. M. C. Hopkins (seated at the left), has appropriately named the "Titanafram," has been developed for use in halls or auditoriums where reception in loud volume is required. It is said that under favorable conditions the volume of sound from it can extend over five miles. This picture shows one of the two experimental instruments now in use.

Re. the Battle for Better Announcing

Whatever our luck may have been in the matter of finding a masterpiece in programs, we have found plenty of public sympathy in our battle for better announcing. The many announcers who have "bawled us out" over various *nom de plumes* will do well to read a few of the legitimate letters that we have received. We are presenting two for examination:

"Dear Sir:—

"Upon several occasions you have distinctly voiced our sentiments about announcers, but what can we do about it? We of the radio audience are placed somewhat, not by choice, but by circumstance, in the beggar class. Since we can not be choosers we patiently listen to the announcer entertain himself, knowing that our time will eventually come to be entertained: therefore I say that we require only the briefest introduction and comment from the announcer. Let the talent entertain, for that's what they're there for. If the announcer must fill in a number, and he should always be suitably prepared against such an emergency, let him do it as an entertainer—without apology and with little comment. Then let the radio audience judge of the merit of his effort.

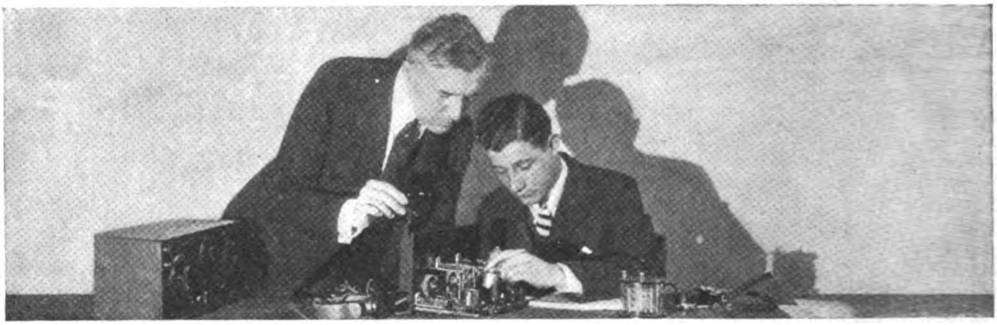
"With the arrangement of program such as I have outlined above, it seems to me that everybody might be suited in part of the program, and almost everybody in all of the program.

J. B. D."

"Dear Sir:—

"Your attention is respectfully invited to the attached article with reference to Announcers. This article 'hits the nail on the head' and is the first truthful criticism regarding announcers that I have seen, all critics appear to be fearful of saying a word to them. Personally I see no use of announcers whatever. When we first had phonographs each record had an announcer, but they died away. A society for the elimination of announcers would have many charter members.

"W. A. S."



IN THE EXPERIMENTER'S LABORATORY

CONDUCTED BY LAURENCE M. COCKADAY

Calibrating an Oscillating Wavemeter

STATION WWV of the Bureau of Standards, in Washington, D. C., has been making a practice of transmitting standard-frequency signals twice each month for the benefit of those who want to calibrate wavemeters or have use for the standard-frequency signals. These transmissions serve as a reliable means for calibration work because of the unquestioned accuracy of the frequencies transmitted.

The transmissions occur on the 5th and 20th of each month, starting at 10 P.M. and lasting until 11.32 P.M., Eastern Standard time. They are arranged on a definite schedule; a certain band of frequencies is transmitted on each of these nights. On October 20, for instance, the band of frequencies from 1,500 to 3,000 kilocycles was covered (200 to 100 meters) as follows:

10.00 to 10.08 P.M.	trans. freq.	1,500	kc	or	200	m.
10.12 to 10.20 P.M.	trans. freq.	1,650	kc	or	182	m.
10.24 to 10.32 P.M.	trans. freq.	1,800	kc	or	167	m.
10.36 to 10.44 P.M.	trans. freq.	2,000	kc	or	150	m.
10.48 to 10.56 P.M.	trans. freq.	2,200	kc	or	136	m.
11.00 to 11.08 P.M.	trans. freq.	2,450	kc	or	122	m.
11.12 to 11.20 P.M.	trans. freq.	2,700	kc	or	111	m.
11.24 to 11.32 P.M.	trans. freq.	3,000	kc	or	100	m.

The transmission is by means of continuous wave telegraphy and it is therefore necessary to use an oscillating receiver in receiving the signals. The procedure of the transmission is to tune the transmitter to 1,500 kc and at 10.00 P.M. the transmission is started on this frequency. Transmission consists of miscellaneous signals, the call of WWV and announcement of the frequency, all in continental code, and a series of dashes. This continues for eight minutes. Four minutes are then allowed to tune the transmitter to the next frequency and from 10.12 to 10.20 the process is repeated at a frequency of 1,650 kc. and so on.

The signals are also transmitted from station 6XBM, Stanford University, California, from 10.00 to 11.32 Pacific Standard time, for the use of those located in the west. Thus the signals are available to anyone in the United States who has a fairly sensitive receiver.

A complete schedule of the transmissions covering a period of four months is given in the monthly *Radio Service Bulletin* which may be obtained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a cost of five cents.

As to actual process of calibrating the wavemeter, a description of the calibration of one of the type described on pages 267-271 of the September, 1925, issue will be useful.

The calibration was made during the transmission on the night of October 20. Unfortunately the experimenter was forced to miss the first three frequencies. Using the other five frequencies, however, four coils for this wavemeter were calibrated, covering from 50 meters up to 555 meters. This, of course, called for the use of the harmonics of the regenerative receiver used for the reception, and of the harmonics of the oscillator wavemeter.

The first frequency tuned in was 2,000 kc or 150 meters (from now on we will refer to wavelengths rather than frequencies). Leaving the receiver tuned to this wavelength, coil X2 (see page 267 of September issue) was inserted in the wavemeter and the wavemeter placed about four feet from the receiver. The wavemeter dial was then slowly rotated until a loud heterodyne whistle was heard in the headphones connected to the receiver, indicating that the wavemeter was tuned to resonance with the receiver, and was therefore tuned to 150 meters. The reading of the wavemeter dial, 88, was then noted and the first point for our calibration curve thus obtained. Moving the wavemeter closer to the receiver the dial was again moved and another heterodyne whistle was heard at 11. This whistle was fainter than the first and the experimenter therefore knew that the wavemeter was tuned to the second harmonic of the received signal, or 75 meters. Thus the second point of calibration was obtained.

Coil X3 was then inserted in the wavemeter and the dial slowly rotated throughout its entire range. Two heterodyne whistles were heard.

one quite strong at 12.5 on the dial and a weaker one at 94. Knowing the range of coil X3 to be somewhere in the neighborhood of 120 to 400 meters it was evident that the low setting was the wavelength to which the receiver was tuned, 150 meters, giving the third point. Turning the dial of the wavemeter to 94 meant that the wavelength to which the wavemeter was tuned was higher; therefore the second harmonic of the wavemeter must be heterodyning with the oscillations of the receiver at 150 meters. This meant that the wavemeter was tuned to twice the wavelength of the receiver, or 300 meters. This was point No. 4 for our curve. When coil X4 was inserted two more heterodyne whistles were heard at 35.5 and 98.5 on the wavemeter dial. The range of coil X4 was known to be about 190 to 600 meters. The dial setting 98.5 was approximately in the middle of the dial range (180 degree dial) therefore the whistle heard there meant that the wavemeter was tuned to 450 meters and the receiver oscillating at 150 meters was heterodyning with the third harmonic. With the wavemeter tuned to the other whistle at 35.5, it was tuned to 300 meters, the second harmonic of which was heterodyning with the received wavelength, 150.

Finally coil X1 was placed in the wavemeter and the wavemeter moved close to the receiver. The range of this coil was known to be about 30 to 100 meters. One heterodyne whistle was heard at 92 on the dial. It was therefore evidently tuned to the second harmonic of the receiver, or 75 meters.

Thus from the one standard signal received on 150 meters two calibration points were found for all the wavemeter coils but the smallest and one point was found for the latter. All of this was accomplished during the 12-minute period of the 150 meter transmission from WWV.

When the transmission was started on 136 meters the same process was repeated. In this case one calibration point was obtained on each of the smaller coils X1 and X2. On X3 two points were obtained and on X4, three points.

From the five frequencies transmitted from WWV the experimenter was able to obtain six points for coil X1, seven for coil X2, nine for coil X3 and fifteen for coil X4. This was enough to make up calibration curves for each of the four coils. The form used in making up the curves were the same as the illustration on page 271 of the September, 1925, issue of Popular Radio.

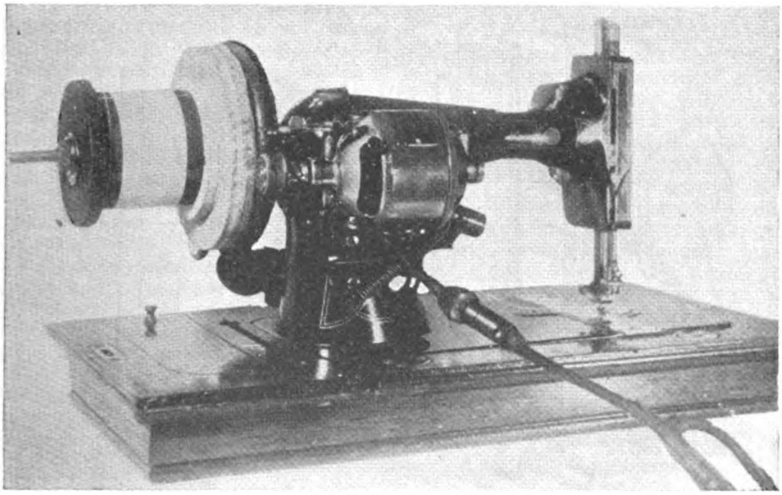
—S. Gordon Taylor

An Efficient Coil Winder

With the aid of two wooden discs, a carriage bolt and a sewing machine, the radio experimenter who winds his own coils can do an infinitely quicker and better job than he can do by the usual method of winding his coils by hand.

Figure 2 shows how the device is attached to a portable electric sewing machine. The apparatus itself, as shown in Figure 3, consists primarily of two wooden discs between which is centered the tube or form upon which the wire is to be wound. These discs are connected together by a carriage bolt, which when tightened holds the tube securely in place.

The thicker of these two discs rests against the flywheel of the machine. It is held in



A COIL WINDING MACHINE

Figure 2: *This picture shows how the ordinary electric sewing machine may be used for winding coils with the aid of a simple attachment.*

place by two or three screw-eyes that pass between the spokes of the flywheel. These screw-eyes hold the disc securely in position. They may be easily unscrewed when the housewife wants to sew.

The winding form, usually a Bakelite tube, is placed between the discs and the bolt is tightened slightly. The machine is then spun slowly and the tube shifted to a central position so that it runs true. The bolt is then fully tightened and the winding started. In this way a coil may be wound in a few minutes that would ordinarily require an hour if done by hand. And when finished, the machine wound coil will not only look better but it may actually be a more efficient coil than one wound by hand.

The so-called "binocular" coils used in both the Grebe and Grimes radio sets may be easily and quickly wound on this machine. This type of coil has somewhat the same electrical characteristics as the toroidal or "doughnut" coils. Incidentally, the binocular coils are wound in pairs but the windings are in opposite directions. (Simply turning a coil, end for end will not reverse the direction of the winding.)

But with the help of this machine, the problem is easily solved.

First, one set of coils is wound, with the motor rotating in one direction. The brushes on the motor are then shifted so as to reverse it. Finally another set of coils may be wound corresponding to the first set but with the windings in the opposite direction so that the fields will be reversed.

—H. G. Bersie.

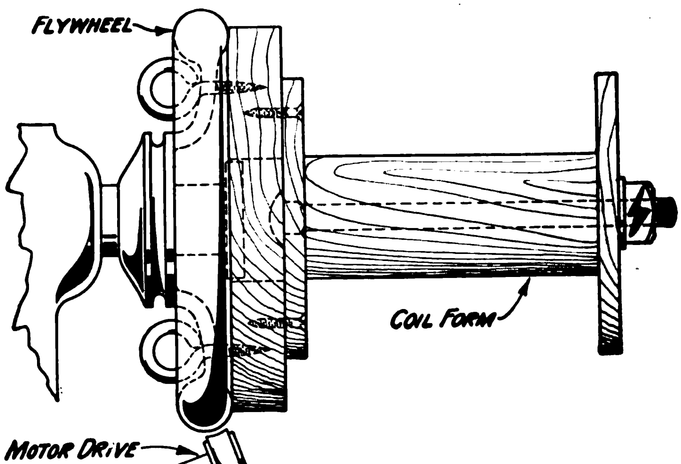
Eliminating that Continuous Whistle

Letters are sometimes received from owners of receivers, in which they state that a receiver which functioned well for some time suddenly developed a tendency to whistle continuously. Sometimes the whistle is high pitched and other times it is in the form of a coarse roar. In some cases, too, the whistle may be noticeable from the first day the receiver is hooked up.

There are various causes of this trouble. Perhaps the most common is defective or worn out "B" batteries.

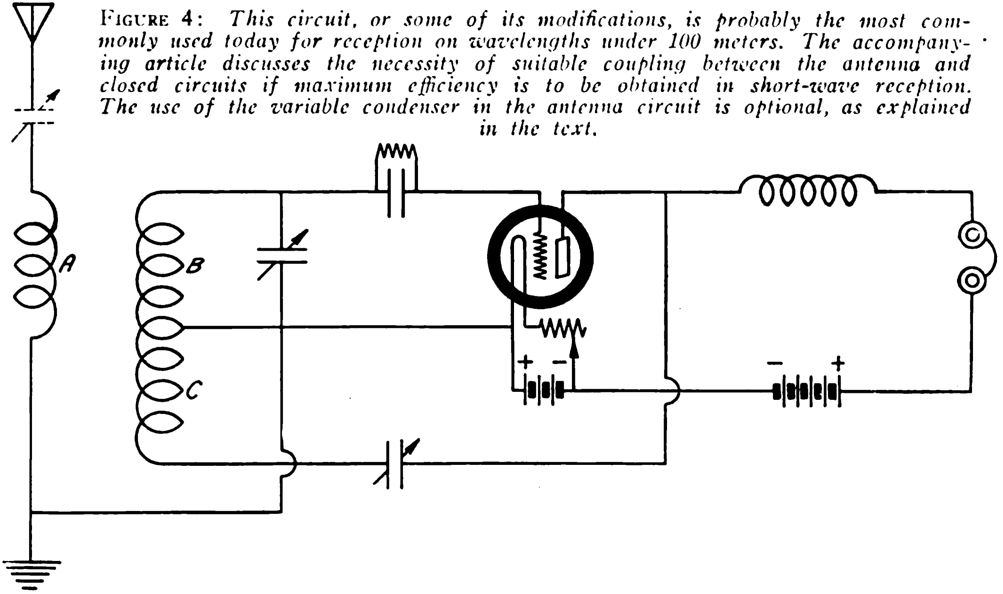
In certain types of receivers one or more worn out "B" batteries will start trouble by first causing a slight but continuous whistle which grows in volume as the batteries run down further. On the other hand it is also possible for a new battery to cause this trouble due to one defective cell. Such a case was experienced recently. A new 22½ volt battery was installed with others in a receiver and immediately a pronounced shrill whistle was noticed. All of the batteries tested over 20 volts, which is high enough for satisfactory operation. Nevertheless the receiver would not whistle with a different set of "B" batteries. Finally a small voltmeter was used to test the individual cells of the batteries and disclosed the fact that one of the cells in the new battery was defective. Its voltage was less than ½ volt. This cell was short circuited with a piece of wire to cut it out of the circuit altogether and the bothersome whistle immediately disappeared.

Often the use of three stages of transformer coupled audio frequency amplification will cause a whistle, and it is for that reason that more than two stages are seldom used in modern receiving set design.



THE WINDING FORM

Figure 3: *This drawing indicates the mechanical construction of the coil winding device and the method of attaching it to the flywheel of the sewing machine.*



THE HARTLEY CIRCUIT

FIGURE 4: *This circuit, or some of its modifications, is probably the most commonly used today for reception on wavelengths under 100 meters. The accompanying article discusses the necessity of suitable coupling between the antenna and closed circuits if maximum efficiency is to be obtained in short-wave reception. The use of the variable condenser in the antenna circuit is optional, as explained in the text.*

If three stages are to be used (with transformers) it is usually quite essential that they be doctored up with fixed condensers and resistances across the transformer windings. Frequently a fixed condenser of about .0005 mfd. capacity across the secondary of the first transformer with a similar condenser and a variable resistance such as the Bradleyohm No. 25 (25,000 to 250,000 ohms) across the secondary of the second transformer will help to eliminate the trouble. Similar doctoring may be necessary in the case of the third transformer too, however.

Where only two stages of transformer coupled audio amplification are used the whistle may also be present, usually due to the use of transformers of poor quality or too high ratio. About 5 to 1 ratio is as high as can safely be used, and even this ratio is advisable only in the case of the first stage of a two stage amplifier. The second stage ratio should be not higher than about 3 or 4 to 1.

Another common cause of a continuous whistle or howl, especially in the present day multi-tube receivers, is the so-called "microphonic howl."

In this case the vibration of the diaphragm of the loudspeaker causes the tubes to vibrate. Usually this sort of a howl builds up until it assumes tremendous proportions. When the receiver is turned on the howl may not be in evidence at all, or else only slightly. Within a very short time, however, it becomes very noticeable, gathering volume as it goes along. In some cases a sudden jar of the receiver will be needed to start it, but once it gets started it can only be stopped by turning off the receiver for an instant.

The first remedy for this type of trouble is to move the loudspeaker as far from the receiver as possible. If this does no good, about the only alternative is to mount the tube sockets on sponge rubber or replace the sockets with the vibrationless type. Often it will be sufficient to do this with the detector tube only. It is also well to try shifting tubes around as some tubes are more "microphonic" than others. Especially in super-heterodyne and other receivers using five or more tubes, a single tube may cause all the trouble. When it is located and replaced the trouble disappears.

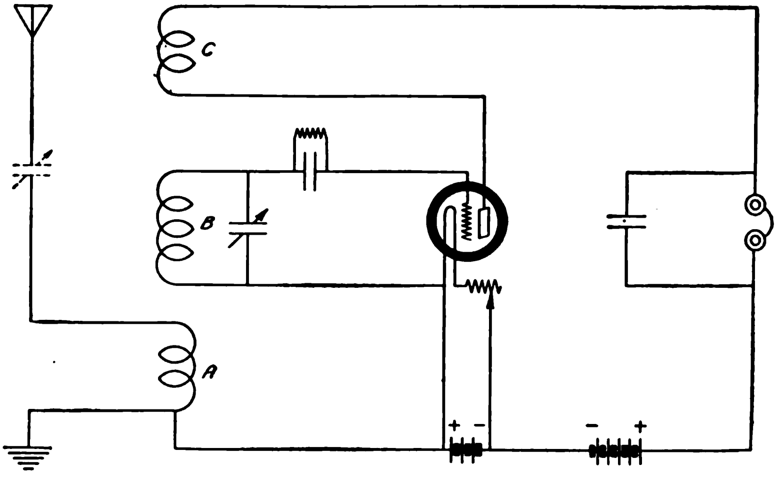
A less frequent cause of the continuous whistle results from running the antenna lead close to, and parallel with, the receiver. It is always advisable to bring the antenna to the receiver from the rear and at a right angle to the back of the receiver. Also run the lead to the loudspeaker directly away from the receiver, and from the body of the operator. In some cases a pronounced whistle is obtained when the operator touches the loudspeaker cord or places his hand near it, especially while his other hand is on the dials in the act of tuning the receiver.

In addition to the type of whistle mentioned here, there are, of course, the whistles frequently encountered in regenerative receivers and in radio frequency amplifiers. These are of a different sort entirely and can be distinguished by the fact that they vary with variations of the tuning controls of the receiver.

Antenna Coupling for Short-wave Receivers

One of the problems in short-wave reception is to obtain proper coupling between the antenna and tube circuits.

To obtain the maximum results and to avoid so-called "dead spots," which are caused by the antenna circuit or one of its harmonics being



THE STANDARD THREE-CIRCUIT TUNER

FIGURE 5: *This is another circuit which is used extensively in short-wave reception. Frequently the type of tuning unit used in this circuit does not permit variation of the number of turns in the antenna coil and in that case a series antenna condenser may be used to decided advantage in the reduction of "dead spots."*

in resonance with the tuned, tube circuit, it is necessary to provide:

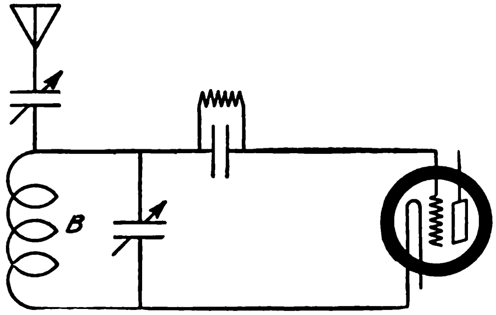
(1) Variable coupling between the antenna coil and the grid coil;

(2) Variable control of regeneration, and,

(3) Some means of partially tuning the antenna circuit.

Practically all short-wave receivers today make use of either the Hartley circuit (Figure 4), the modified Reinartz (which is practically the same as the Hartley), or the standard three-circuit hook-up using primary, secondary and tickler (Figure 5). This article, therefore, refers particularly to these circuits.

If an untuned antenna circuit is used with a receiver designed to cover the short-wave bands from 30 to 120 meters and providing controls for (1) and (2) above, it will be found that at certain wavelengths it is impossible to make the receiver oscillate unless the coupling between the antenna and closed circuit coils is loosened to such an extent as to make signals extremely weak. This condition results from the condition of broad resonance of the antenna circuit with the closed circuit and absorbs enough energy from the closed circuit to stop oscillation. If the coupling between antenna and closed-circuit coils is loosened sufficiently, the antenna circuit absorbs less energy and therefore does not so readily stop oscillation. This loose coupling decreases the signal strength, however, due to the smaller energy transfer from the antenna circuit to the closed circuit.



DIRECT ANTENNA COUPLING

FIGURE 6: *Some degree of success has been met with in coupling the antenna directly to the closed circuit through a series antenna condenser as shown here. This method may be used with either of the hook-ups shown in Figures 4 and 5, thus eliminating the necessity for antenna coils. Coupling is varied by means of the antenna series condenser.*

Now, with the coupling fairly close, oscillation would not stop if the antenna circuit could be tuned sufficiently to shift its wavelength either up or down so that it, or its harmonics, would no longer be in resonance with the closed circuit.

This broad tuning of the antenna circuit may be accomplished in a variety of ways. The most satisfactory plan, in the case of the Hartley type of circuit, is to provide two or more different coils for the antenna circuit.

If it is desired to tune the circuit to a certain wavelength but it is found that even with fairly loose coupling the receiver will not oscillate satisfactorily at that wavelength, an antenna coil with a different number of turns is substituted, thus shifting the wavelength of the antenna circuit to a point where it no longer interferes with the functioning of the tube circuit.

In the Hartley type of receiver, a single closed-circuit coil will not, of course, cover the entire 30 to 120 meter band. Because of the extremely sharp tuning at low wavelengths it is advisable to use a low capacity tuning condenser and this naturally limits the range of each closed-circuit coil so that three or perhaps four coils are needed to cover this entire band. Using a three plate condenser (maximum capacity .000045) across the grid portion of the closed-circuit coil, four coils are needed. The range of the smallest coil may be approximately from 30 to 45 meters, the next one from 45 to 65, the next 60 to 90 and the largest 80 to 120. Three antenna coils of 5, 13 and 21 turns respectively, will probably serve to tune the antenna. This, however, will depend a good deal upon the proportions of the antenna that is used. Antennas of all lengths seem to work out about equally well for short-wave reception —a single wire anywhere from 25 to 150 feet will be satisfactory.

Another method of tuning the antenna is by means of a very small variable condenser in series with the antenna as shown by the broken lines in Figures 4 and 5.

Usually, by this means, it is possible to reduce the number of antenna coils needed to two or even one. In the case of three-circuit tuners, in which no provision is made for changing antenna coils, the use of an antenna, series condenser will be found especially useful.

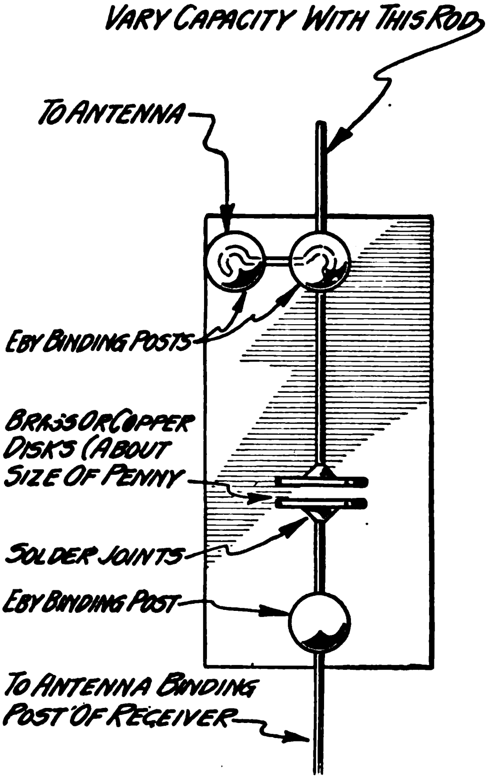
A third method which has met with some success is that illustrated in Figure 6.

By the use of this method, the antenna coil is eliminated entirely and the antenna is connected directly to the grid end of the closed-circuit coil, through the antenna series condenser. This method controls the amount of coupling between antenna and closed circuit by means of a variable condenser.

The maximum capacity of series antenna condensers used for this short-wave work will depend to some extent on the size of the antenna used. The best plan in any particular installation is to try out different condensers until the best one is found. A three or five-plate variable condenser will in some cases work out quite satisfactorily, while in other cases a simple homemade device as illustrated in Figure 7 will serve the purpose, especially if the receiving antenna is large.

Every owner of a short-wave receiver should experiment a little with various antennas, antenna coils, series antenna condensers, and various degrees of coupling. Many of these receivers in operation at the present time are not giving anywhere near the results of which they are capable, simply because the coupling arrangement used is not suitable. A receiving range of 10,000 miles is not too much to expect of any efficient short-wave receiver in reception of amateur code signals. In short-wave broadcast reception the range is bound to be somewhat less. However many South American listeners are enjoying the programs broadcast nightly from KDKA at Pittsburgh, on a wavelength around 60 meters, at distances of 3000 miles and more.

—S. Gordon Taylor


VARY CAPACITY WITH THIS ROD
TO ANTENNA
EBY BINDING POSTS
BRASS OR COPPER DISKS (ABOUT SIZE OF PENNY
SOLDER JOINTS
EBY BINDING POST
TO ANTENNA BINDING POST OF RECEIVER

A SIMPLE HOME-MADE ANTENNA SERIES CONDENSER

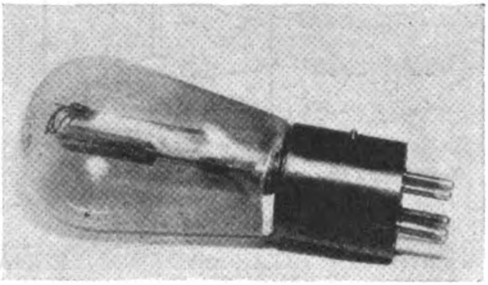
Figure 7: *In some cases a regular* .0001 *or* .00025 *mfd. variable condenser will serve as the series antenna condenser for use in short wave reception. As a rule, however, it is necessary to use extremely low values of capacity for this purpose. The simple condenser shown here serves the purpose well.*

A Receiver That Will Operate on 50 to 550 Meters

In the March issue of Popular Radio will appear an article containing complete information on the constructional details for building a new receiver that will operate over a band of wavelength from 50 to 550 meters. This description will be of interest alike to the seasoned amateur and experimenter as well as the inexperienced novice. It is probably the first tuned-radio-frequency receiver that has as yet been described for operating over such a wide wavelength band. One exclusive feature of the new receiver is that the wiring is prepared in advance for the experimenter so that all he has to do is to hitch it on to the set. It is the result of collaboration on the part of two engineers—McMurdo Silver and Laurence M. Cockaday and it will be known as the S-C Receiver.

WHAT'S NEW IN RADIO APPARATUS

This *department is conducted by* **Popular Radio Laboratory** *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*



A Tube for Greater Volume

A NEW POWER TUBE

Name of instrument: UX-210 vacuum tube.

Description: This new tube which contains a husky thoriated filament is especially manufactured for use in the last stage of audio-frequency amplification where great volume is desired. It is also a reliable oscillator for laboratory work. It may be operated directly from a 6-volt storage battery on the filament without rheostat with 157 volts on the plate. With 7½-volts filament potential across the terminals of the tube, it may be used with plate batteries as high as 425 volts with a 35-volt "C" battery. At this voltage it has an output resistance of 5000 ohms, conductance of 1550 micromhos and a voltage amplification factor of 7.75. It is equipped with the large standard UX base.

Usage: In connection with radio receiving apparatus for use as a power tube.

Outstanding features: Rugged construction. Reliable operation. Powerful.

(*Further details furnished on request*)

A TWIN ELEMENT VARIABLE CONDENSER

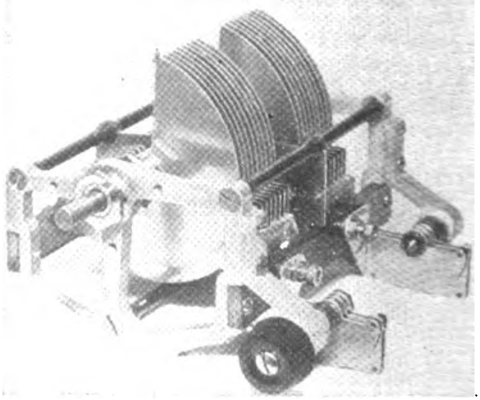
Name of instrument: Dual variable condenser.

Description: A really well made tuning unit comprising two sets of stator and rotor plates with two variable vernier units for adjusting them to the same capacity. One of the vernier controls is adjusted from the front panel of the set on which the set is mounted. The end plates are constructed of die cast aluminum cut away as shown in the photograph. The insulation is accomplished by means of two clear bakelite strips upon which the stator elements are mounted. The bearing, which is large, is fitted with a novel tension adjustment, which, although it varies the tension on the shaft, does not vary the spacing between the plates and between the rotor and stator sections.

Usage: In any radio-frequency circuit for tuning.

Outstanding features: Dual operation with single shaft. Rugged construction. Easy to balance. Neat appearance. Equipped with a shield between the stator elements.

(*Further details furnished on request*)



A Dual Unit With Verniers

Apparatus Approved by Popular Radio

This list of apparatus approved by the POPULAR RADIO LABORATORY will be continued as a part of the WHAT'S NEW IN RADIO APPARATUS department until all instruments, parts and complete sets have been included. The listing is alphabetical by manufacturer's name and the installment in this issue includes only the letters A and B.

AERIALS

Stranded enameled antenna; Acme Wire Co.
"Ribbon" copper aerial; Acorn Radio Mfg. Co.
Enameled ribbon aerial; Acorn Radio Mfg. Co.
Hollow radio aerial; American Display Co.
Antennaphone; Antennaphone Co.
Flat copper antenna ribbon; Baltimore Brass Co.
Beldenamel aerial wire; Belden Mfg. Co.
"Storm King" complete aerial outfit; L. S. Brach Mfg. Co.

AUDIO-FREQUENCY TRANSFORMERS

"Acme" audio-frequency transformer; Acme Apparatus Co.
Algo audio-frequency amplifying transformer; Algonquin Electric Mfg. Co.
Rauland-Lyric audio-frequency transformer; All-American Radio Corp.
All-American audio-frequency amplifying transformer; All-American Radio Corp.
Audio-frequency transformers; American Specialty Co.
Amertran DeLuxe transformer; American Transformer Co.
"Fada" audio-frequency transformer; F. A. D. Andrea, Inc.
"King Cole" audio-frequency transformer; Anylite Electric Co.
Brandes audio-frequency transformer; Brandes Products Corp.
Branston audio-frequency transformer; Chas. A. Branston, Inc.

BATTERIES

"Arrow" storage batteries; Arrow Battery Co.
Radio "B" Batteries at "factory prices"; Ayres Battery Corp.
Burgess "A," "B" and "C" batteries; Burgess Battery Co.

BATTERY CHARGERS AND RECTIFIERS

"Acme" battery charger; Acme Electric & Mfg. Co.
Silent battery charger; Acme Engineering Co.
"Apco" "A" and "B" battery chargers; Apco Mfg. Co.

BATTERY ELIMINATORS

"Acme" "B" eliminator; Acme Apparatus Co.
"Apco" rectodyne; Apco Mfg. Co.

BINDING POSTS

Ajax binding posts; Ajax Electric Specialty Co.
Bel-Tone mounted binding posts; Bel-Tone Radio Co.

CRYSTAL DETECTORS

Syn-tec radio crystal; Appliance Radio Co.
"Airader" detector; Bernard's Radio Co.
"B Metal" crystal; B-Metal Refining Co.

DIALS

Na-ald dials; Alden Mfg. Co.
Bradleynier; Allen-Bradley Co.
Radion knobs and dials; American Hard Rubber Co.
Split-Em vernier instrument control; American Instrument Works.
Regal knobs and dials; American Specialty Co.
Amsco dials; Amsco Products, Inc.
Apex vernier dial; Apex Electric Mfg. Co.
Bell dial; Bell Mfg. Co.

FIXED CONDENSERS

Mica fixed condenser; Aerovox Wireless Corp.
Aerovox bypass condenser; Aerovox Wireless Corp.

GRID-LEAKS AND RESISTANCES

Tubular grid-leak; Aerovox Wireless Corp.
Bradleyleak; Allen-Bradley Co.
Bradleyohm; Allen-Bradley Co.
Bradleyunit; Allen-Bradley Co.
Clarostat; American Mechanical Labs.
Amplex Lavite resistance; Amplex Instrument Labs.
Amplex grid-leak; Amplex Instrument Labs.
Arbee grid-leaks and resistances; Arbee Mfg. Co.
Grid-leak; A. C. Brady Co.
Volt-X variable grid-leak; Burton & Rogers Mfg. Co.
Volt-X grid-leak mounting; Burton & Rogers Mfg. Co.

HEADPHONES

Bel-Canto headset; Bel-Canto Radio & Tel. Equipment Co., Inc.
Berstan headset; Berstan Radio Products.
Navy type headset; Brandes Products Corp.
Superior headset; Brandes Products Corp.

JACKS

Radio jack; Adams Radio Mfg. Co.
Amplex jack; Amplex Instrument Labs.
Tri-jack; Brooklyn Metal Stamping Co.
"B. M. S." jack; Brooklyn Metal Stamping Co.

KITS

A-C Dayton XL-5 Knocked Down Set; A-C Electrical Mfg. Co.
Acmeflex kit; Acme Apparatus Co.
All-Amax Senior kit; All-American Radio Corp.
"Cockaday" and "Tobias" kits; Amplex Instrument Labs.
Neutrodyne, Superheterodyne and Tobias kits; Amplex Instrument Labs.
Melco Supreme kits; Amsco Products, Inc.
"Fada" neutrodyne kit; F. A. D. Andrea, Inc.
Superheterodyne kit; Apex Electric Mfg. Co.
"Pacific Rainbow" Super-Het kit; Baldwin Pacific & Co.
Bel-Tone Superdyne kit; Bel-Tone Radio Co.
Dyne-O-Might kit; Birch-Field Radio Corp.
Superheterodyne kit; J. T. Boone Radio Corp.
Superheterodyne kit; Charles A. Branston, Inc.
B-T R.F. Circuit; Bremer-Tully Mfg. Co.

LOOPS

Aalco folding loop; Aalco Radio Laboratories, Inc.
Amplifex loop; Amplifex Radio Corp.
Berling loop; Berling Magneto Co.
Basket-weave folding loop aerial; Bodine Electric Co.
Super-folding loop aerials; J. T. Boone Radio Corp.

LOUDSPEAKERS

Royal radio speaker; Adler Mfg. Co.
Junior Ambotone; American Bosch Magneto Corp.
Ambotone reproducer; American Bosch Magneto Corp.
Burns loudspeaker; American Electric Co.
Amplion loudspeaker; Amplion Corp. of America
Bell-type speaker; Apex Electric Mfg. Co.
Armstrong speaker; Armstrong Speaker Co.
Atwater Kent loudspeaker; Atwater Kent Mfg. Co.
Bel-Canto loudspeaker; Bel-Canto Radio & Tel. Equip. Co.

A VARIABLE RATIO VERNIER DIAL

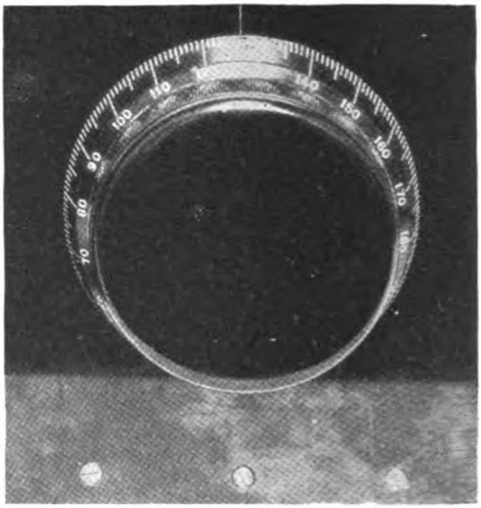
Name of instrument: SLF converter tuning dial.

Description: This dial is designed to operate with an ordinary straight-line-capacity condenser for obtaining straight-line-frequency tuning. It accomplishes the same results as using a straight-line-frequency condenser with an ordinary dial. The condenser shaft itself is fastened to a lever which operates in a spiral cam slot which is mounted on the dial bearing. Throughout the first lower settings of the dial, the condenser revolves much slower than the dial itself, but this ratio of movement of the condenser and the dial increases until at the upper settings of the dial, the condenser is moving at an increased rate. The rate of change of capacity with dial setting is of course correct for producing straight-line-frequency tuning when used in connection with the proper coil and condenser that will cover the wavelength band that it is desired to operate over.

Usage: In any radio-frequency circuit for controlling the tuning apparatus.

Outstanding features: Efficiency. Straight-line-frequency tuning. Smooth operation. Converts old sets to the new style of tuning. 360 degree operation.

(Further details furnished on request)



A New Converter for SLF Tuning

Bel-Canto cabinet speaker; Bel-Canto Radio & Tel. Equip. Co.
Semi-console cabinet (combination horn and cabinet); Blandin Phonograph Co., Inc.
"Sonochorde" loudspeaker; Bondette Mfg. Co.
Brandes speaker, type H; Brandes Products Corp.
Brandes cone-type loudspeaker; Brandes Products Corp.
Brandes cabinet speaker; Brandes Products Corp.
Orchestrion De Luxe; F. Bremerman & Sons
Bristol Audiophone loudspeaker; Bristol Co.

MISCELLANEOUS ACCESSORIES

"Spaghetti"; Acme Wire Co.
Window lead-in; Acorn Radio Mfg. Co.
"Little Jiant" circuit breaker; Bruno H. Ahlers
Na-ald sponge rubber cushion; Alden Mfg. Co.
Standard tube base; Alden Mfg. Co.
Allen special radio soldering paste; L. B. Allen Co., Inc.
Alpha "Special" spaghetti; Alpha Radio Supply Co., Inc.
Insulated, square and round bus bar wire; Alpha Radio Supply Co., Inc.
Bosch Nobattery; American Bosch Magneto Corp.
Radion loudspeaker horn; American Hard Rubber Co.
Radion loudspeakerphone cap; American Hard Rubber Co.
Coil mount; American Radio & Supply Co.
Spaghetti tubing; American Radio & Supply Co.
"Nifty" lead-in; Amoroso Mfg. Co.
"Nifty" ground clamp; Amoroso Mfg. Co.
Apollo nickel zinc; Apollo Metal Works
Adaunit; Auto Indicator Co.
Porcelain pedestal; Barkelew Electric Mfg. Co.
Ear cushion for phones; Bates & Co.
Belden battery cords, headset cords, tips and terminals; Belden Mfg. Co.
B-H radio tubing; Bentley-Harris Mfg. Co.
Blackburn ground clamp; Blackburn Specialty Co.
Bearings for radio tuning coils; Edward Board

PANELS

Radion panels; American Hard Rubber Co.
Condensite products; Bakelite Corp.
Bakelite products; Bakelite Corp.
Redmanol products; Bakelite Corp.

PHONE PLUGS

Ajax multi-phone plug and connector; Ajax Electric Specialty Co.
Multiple phone plug; Barkelew Electric Mfg. Co.
Series phone plug and post; Barkelew Electric Mfg. Co.
Series phone plug for binding post mounting; Barkelew Electric Mfg. Co.

PHONOGRAPH ATTACHMENTS

Burns Concert loudspeaker unit; American Electric Co.
Amplion phonograph unit; Amplion Corp. of America

POTENTIOMETERS

Bradleyometer; Allen-Bradley Co.
Regal potentiometer; American Specialty Co.
Amsco potentiometer; Amsco Products, Inc.
Amsco "Dublwundr" potentiometer-rheostat; Amsco Products, Inc.
"Fada" potentiometer; F. A. D. Andrea, Inc.

POWER AMPLIFIERS

One stage power amplifier; Bristol Co.

RADIO CABINETS

Radio cabinet; A. Hall Berry
Blandin radio cabinet; Blandin Phonograph Co., Inc.

RADIO-FREQUECNY TRANSFORMERS

"Acme" radio-frequency transformer; Acme Apparatus Co.
"Acme" "D" unit (tuned radio-frequency transformer with condenser); Acme Apparatus Co.
Radio-frequency transformer; Aero Products, Inc.
All-American radio-frequency transformer; All-American Radio Corp.
Amsco radio-frequency transformer; Amsco Products, Inc.
Radio-frequency tuned transformer; Benjamin Electric Mfg. Co.
Branston radio-frequency transformer; Chas. A. Branston, Inc.

"Tri-Coil" radio-frequency transformer; Brooklyn Metal Stamping Co.

RECEIVING SETS

A-C Dayton XL-10 receiver; A.-C Electrical Mfg. Co.
A-C Dayton receiver; A-C Electrical Mfg. Co.
"Paragon" receivers; Adams-Morgan Co.
Adler-Royal neutrodyne; Adler Mfg. Co.
Torodyne receiver; Ainsworth Radio Co.
Air-Way receivers; Air-Way Electric Appliance Corp.
Ajax crystal receiving set; Ajax Electric Specialty Co.
All-American receiver; All-American Radio Corp.
Amber Marv-O-Dyne 5-tube set; Amber Sales Corp.
Bosch receiver; American Bosch Magneto Corp.
Electrola receiver; American Specialty Co.
Amplex DX5 receiver; Amplex Instrument Labs.
Melco Supreme receiver; Amsco Products, Inc.
Deresnadyne broadcast receiver; Andrews Radio Corp.
King Cole receiver; Anylite Electric Co.
Apex Super 5 receiver; Apex Electric Mfg. Co.
Microdyne receiver; Apex Electric Mfg. Co.
Atwater Kent radio-frequncy receiver; Atwater Kent Mfg. Co.
Standard "B" pocket radio; Auto Indicator Co.
Aragain radio receiver; Autometal Corp.
Baby Grand crystal receiver; Beaver Machine & Tool Co., Inc.
Biltmore Master Reflex receiver; Biltmore Radio Co.
Dyne-O-Might receiver; Birch-Field Radio Corp.
Blair No. 11 receiver; Blair Radio Laboratories
Brandola receiver; J. F. Brandeis Corp.

RHEOSTATS

"Acme" rheostat and potentiometer; Acme Apparatus Co.
Bradleystat; Allen-Bradley Co.
Regal rheostat; American Specialty Co.
Amplex rheostat; Amplex Instrument Labs.
Amsco rheostat; Amsco Products, Inc.
Amsco double rheostat; Amsco Products, Inc.
Amsco "Dublwundr" rheostat-potentiometer; Amsco Products, Inc.
"Fada" rheostat; F. A. D. Andrea, Inc.
Brach-stat; L. S. Brach Mfg. Co.

SOCKETS AND ADAPTERS

Na-ald sockets and adapters; Alden Mfg. Co.
All-American radio tube socket; All-American Radio Corp.
Radion socket; American Hard Rubber Co.
Amplex socket; Amplex Instrument Labs.
Amsco socket; Amsco Products, Inc.
Baldwin-Pacific Super Lo Wave adapter; Baldwin-Pacific & Co.
Belden socket; Belden Mfg. Co.
Bell socket; Bell Mfg. Co.
Cle-ra-tone socket; Benjamin Electric Mfg. Co.
Seven and eight socket shelves; Benjamin Electric Mfg. Co.
V. T. Sockets; Bennington Radio & Electric Mfg. Co., Inc.
Flewelling socket; Buell Mfg. Co.

SWITCHES

Fil-fone control switch; A.C Electrical Mfg. Co.
Bradleyswitch; Allen-Bradley Co.
Regal switches; American Specialty Co.
Amsco switches; Amsco Products, Inc.
"Kant-Blo" signals; Apex Radio Co.
Combined switch and arrester; Barkelew Electric Mfg. Co.
Antenna selector switch; Barkelew Electric Mfg. Co.
Battery switch; Benjamin Electric Mfg. Co.
Single and double inductance switches; Bruno Radio Corp.

TESTING INSTRUMENTS

Perfection hydrometer; Bemco Mfg. Co.
Hoyt tube tester; Burton & Rogers Mfg. Co.
Voltmeters; Burton & Rogers Mfg. Co.

TUBES

"Sea Gull" amplifier and detector tube "E"; Aberdeen Specialty Co., Inc.
"Sea Gull" rectifier tubes; Aberdeen Specialty Co., Inc.
Raytheon tube; American Appliance Co.
Bluebird tube; Bluebird Tube Co.
Vacuum tube; Brendonne Corp.
"True Blue" vacuum tube; Brightson Laboratories, Inc.

TUNING INDUCTANCE UNITS

"Copp" vario elector; A-C Electrical Mfg. Co.
A-C Dayton complete units; A-C Electrical Mfg. Co.
A-P coils; Acme Products Co.
Aero coil tuning inductances; Aero Products, Inc.
All-American toroid coils; All-American Radio Corp.
All-American radio-frequency coupler; All-American Radio Corp.
Amsco honeycomb coils; Amsco Products, Inc.
Amsco variometer; Amsco Products, Inc.
Honeycomb coils; Atwood Electric Co.
Bel-Tone variocoupler; Bel-Tone Radio Co.
B & P micrometer-type low-loss tuner; Barrett & Paden
Bel-Tone variometer; Bel-Tone Radio Co.
Bel-Tone filter tuner; Bel-Tone Radio Co.
Bel-Tone Major tuner; Bel-Tone Radio Co.
Branston oscillator coupler; Chas. A. Branston Inc.
Branston honeycomb coil; Chas. A. Branston, Inc.
Branston three-coil mounting; Chas. A. Branston, Inc.
Heterus coil; Chas. A. Branston, Inc.
Bruno "77" low-loss tuning coil; Bruno Radio Corp.
Bruno low-loss tuned radio-frequency coil; Bruno Radio Corp.
Bruno short-wave tuning coil; Bruno Radio Corp.
Flewelling tuner; Buell Mfg. Co.

TOOLS AND EQUIPMENT

Jack wrench; Adams Radio Mfg. Co.
Condenser plate cleaner; Atwood Electric Co.
"Solderette" electric soldering iron; Bechler Steel Products Co.
Junior bench saw; W. B. & J. C. Boice.
B-T low-loss tuner; Bremer-Tully Mfg. Co.
Bruno engraving set; Bruno Radio Corp.

VARIABLE CONDENSERS

"Acme" variable condenser; Acme Apparatus Co.
Bradleydenser; Allen-Bradley Co.
Worm-drive vernier condenser; American Brand Corp.
Kelford variable condenser; American Specialty Co.
Amplex grid-denser; Amplex Instrument Labs.
Amsco low-loss variable condenser; Amsco Products, Inc.
Amsco straight-line-frequency condenser; Amsco Products, Inc.
"Fada" variable condenser; F. A. D. Andrea, Inc.
Variable condenser; Barrett & Paden.
Variable air condenser; Beacon Radio Mfg. Co.
Low-loss condenser; Benjamin Electric Mfg. Co.
Turn-it adjustable condenser; Chas. E. Bonine
Super variable condenser; J. T. Boone Radio Corp.
B-T Lifetime condenser; Bremer-Tully Mfg. Co.
B-T tandem condenser; Bremer-Tully Mfg. Co.
3 in 1 variable condenser; Bruno Radio Corp.
Flewelling condenser; Buell Mfg. Co.

WIRE

"Celatsite"; Acme Wire Co.
Battery cable; Acme Wire Co.
Alpha square, round and insulated bus bar wire; Alpha Radio Supply Co., Inc.
Gosilco; American Luminous Products Co.
Belden loop wire; Belden Mfg. Co.
Belden Litz wire; Belden Mfg. Co.
Belden hook-up and magnet wire; Belden Mfg. Co.

WITH THE INVENTORS

CONDUCTED BY WILLIAM G. H. FINCH

THIS *department will keep you in touch with the latest inventions of interest on which patent rights have been granted, and which are significant contributions to radio art.*

Tuning in the Stations by Name

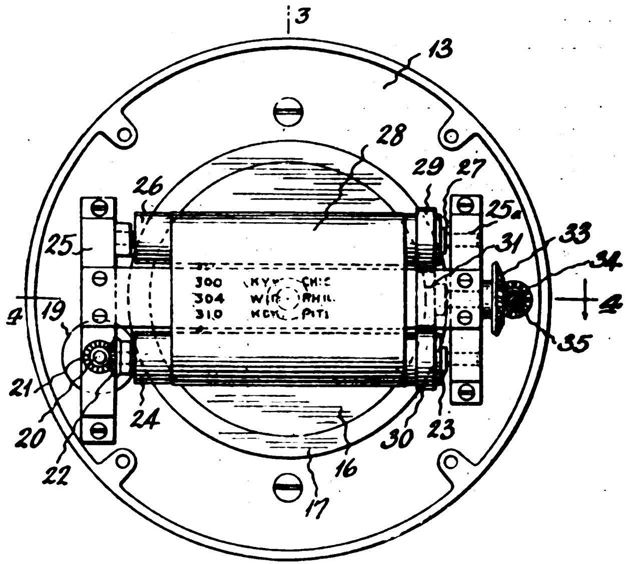
THERE is an idea for a station indicator that greatly simplifies tuning in patent No. 1,555,743, which was issued to E. G. Ballenger of Atlanta, Ga.

An object of the invention is to provide a simple attachment which can be easily applied to any panel-board and connected to the shaft of a tuning element. Then as a portion of the indicator is moved, space for the names of the broadcasting stations will successively appear through a slot in the panel.

The invention comprises a casing which is somewhat like a radio tuning dial in appearance. Within this casing is placed a movable strip on which may be listed the names of the various broadcasting stations.

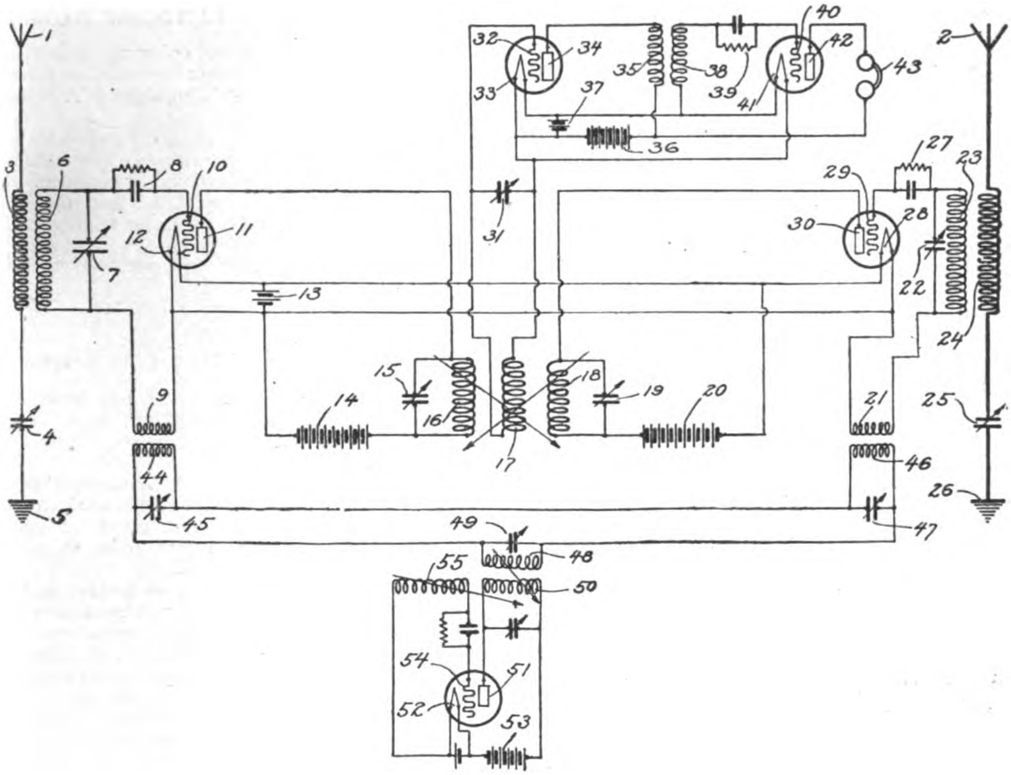
This strip is connected by suitable gearing to the shaft of a tuning element forming part of the radio set so that as the dial is moved, and the set is tuned to various stations the strip moves, bringing into view in the slot the names of these stations. Therefore, if a person wants station WEAF of New York he does not have to remember the wavelength; he need but turn dial or dials until the name or call letters of this particular station appear through the slot.

One form of the station indicator is shown in Figure 1.



THE BALLENGER STATION INDICATOR

FIGURE 1: *This drawing shows the details of the invention; on the moving strip is shown how the stations are listed, and also the simple system of gears.*



A SYSTEM OF CONTINUOUS WAVE RECEPTION

Figure 2: *This diagram illustrates a receiving system in which two differently tuned receiving circuits are balanced against each other. A beat note, which is substantially the same in both circuits, is produced by means of a local oscillator and undesired frequencies are balanced out while retaining the desired signals.*

A Novel Scheme for "Eliminating Static"

Le Roy E. Humphries, of Atlanta, Ga., was recently granted Letters Patent No. 1,549,310, "on a radio receiver and static elimination system."

This invention relates broadly to radio communication, but more particularly to a radio receiving system used for the reception of high frequency current signals wherever they are subject to interference from "static" or strays of an untuned or aperiodic character. These strays excite the receiving system by shock excitation or by induction, leaving it free to oscillate at its own natural period or to the interference that is offered by local transmitters in proximity to the receiving station.

A system is provided for the reception of signals so that the detrimental or interfering effect of the static or stray currents is minimized or eliminated, thus providing a more reliable and efficient system for reception.

Another object of the invention is to provide a circuit arrangement for a receiving station so as to make possible the simultaneous transmission and reception of signals. To this end the transmitter is located in close proximity to the receiving station, but produces no interference with the functioning of the receiving apparatus.

There is also a receiving circuit arrangement that has a pair of differently tuned energy collecting circuits that are connected to differentially coupled circuits which are tuned to substantially the same frequency. A separate circuit is cumulatively coupled with the resultant field of the differentially coupled circuits and connected to an independent radio receiving apparatus which, by virtue of the differential operation of the associated circuits, will respond to a selected incoming frequency to the exclusion of strays or undesired frequencies.

Another object of the invention is to provide a receiving system that is particularly adapted to continuous wave reception. A pair of differently tuned receiving circuits are balanced against each other and a local source of oscillations is supplied to each circuit through a link circuit that has branches coupled one to each of the receiving circuits and each tuned to a frequency equal to the frequency of the opposite receiving circuit. In this way a resultant beat note of substantially the same frequency in each receiving circuit is produced and undesired frequencies and strays are balanced out while retaining the desired signal. (See Figures 2 and 3.)

A Telephone Receiver as a Loudspeaker

Henry G. Sall of Chicago has been granted patent No. 1,552,959 covering a telephone receiver in which the armatures of the polarized electromagnets are connected with the receiver diaphragm by means of a link which serves to transmit the vibrations. This instrument, which may be used as a loudspeaker, is shown in cross section in Figure 4.

The diaphragm of this receiver may be made of any suitable resilient sheet material such as mica, bakelite or a suitable metal, and is tensioned to resist deflection from its normal plane in either direction. A link connects the diaphragm with the receiver armature in such a way as to maintain a fixed distance between them. In this way the diaphragm may position the armature centrally between the magnet poles and resist the movement of the armature from its central position.

The employment of a resilient coupling between the link and diaphragm prevents grating noises and preserves, unimpaired, the mechanical union between these parts.

A Simple Crystal Detector Mount

Patent No. 1,554,640, covering a simple method for mounting crystals for radio detection purposes was issued recently to Volney T. Miller of Kansas City, Mo.

This is a combination of a crystal detector element with a mutual mounting. The mounting has a series of parallel grooves or corrugations across its face, while the apex of a part of these grooves has ends overlapping the edge of the crystal.

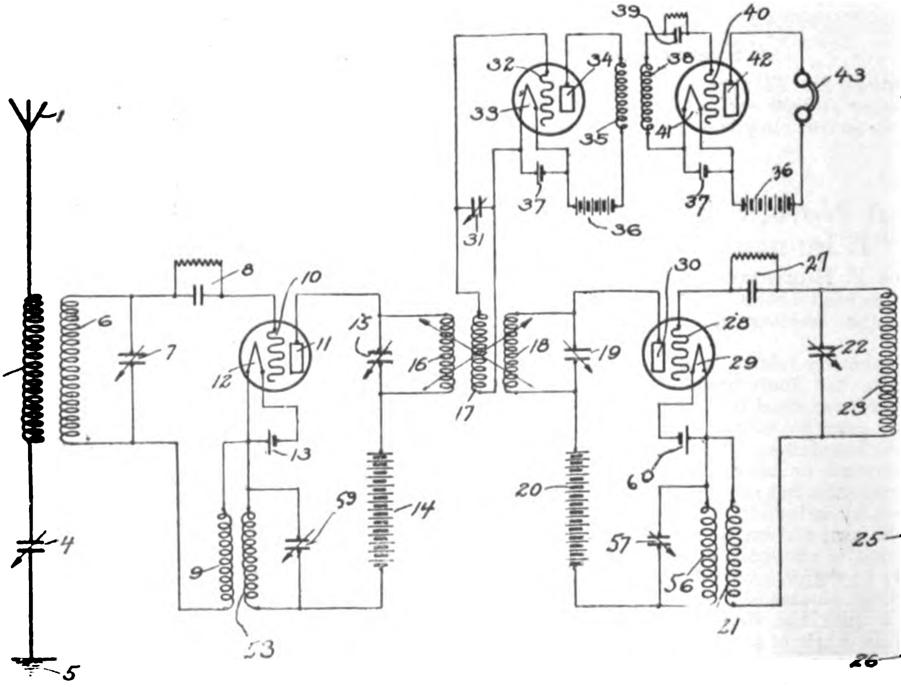
Figure 5 shows the device in perspective; the grooving may be plainly seen.

A Variable Mercury Condenser

A recent patent, No. 1,553,766, issued to Charles A. Friedrich of Brooklyn, New York, covers a variable mercury condenser, illustrated in Figure 6.

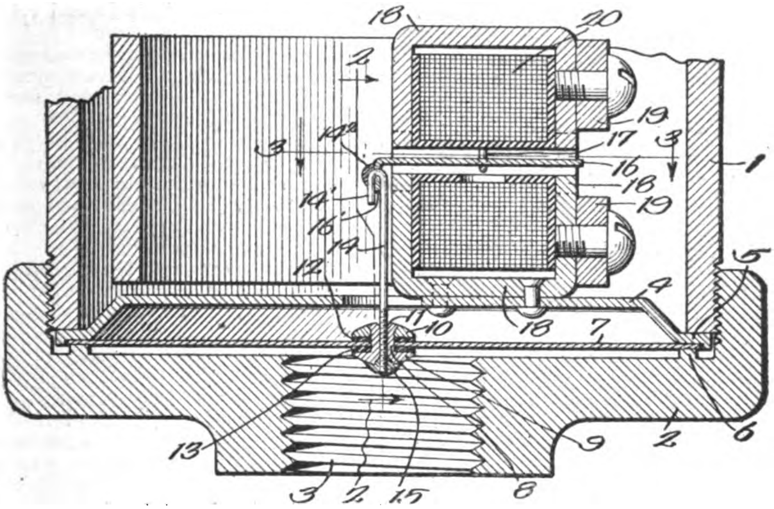
Mercury-controlled devices have nearly always been found unsatisfactory for radio work in the past, because they have not given accurate enough adjustments; therefore most of them were abandoned in the laboratory.

One fault in mercury-controlled devices has been the imperfections in construction and in the material used for the mercury containers. It has been found that the container, in order to permit the use of mercury as a controlling ele-



A VARIATION OF THE HUMPHRIES SYSTEM

Figure 3: *Another form of the system for continuous wave reception in which each of the receivers operates with self-excited oscillations for beat reception.*



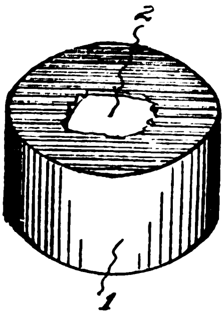
THE SALL TELEPHONE RECEIVER

Figure 4: *This shows a cross section of the construction of this new receiver in which the armatures of the polarized electromagnets are connected with the diaphragm indirectly by means of a link. A resilient coupling is employed between the link and the diaphgram to prevent grating noises and insure good mechanical connection.*

ment, must be so constructed that the surface tension will always cause the mercury to move as a continuous mass. In other words, the cohesion of the molecules of mercury must be increased to resist the attraction or adhesion of the walls of the container, which tends to break up the mercury mass.

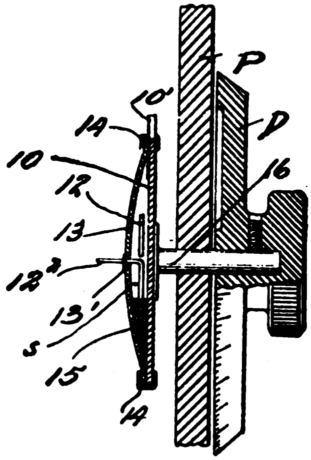
This end is accomplished in Mr. Friedrich's invention by using a circular container of which one or both face walls are spherically curved or convexed; in this way the mercury mass that fills only a part of the container diminishes in thickness from the center toward the periphery of the container. By reason of the greater weight at its wider or thicker part, the surface tension of the mercury is considerably increased and the molecules at the narrower parts resist the force of adhesion exerted by the walls of the chamber.

Having overcome the difficulties in the use of mercury as a controlling element, use may be readily made of it in the construction of grid-leaks, rheostats and variable condensers, greatly



A SIMPLE MOUNTING FOR CRYSTALS

Figure 5: *A series of parallel grooves or corrugations run across the face of this mounting for detector crystals. The center grooves overlap the face of the crystal.*



A NEW VARIABLE MERCURY CONDENSER

Figure 6: *A cross-sectional view of the Friedrich condenser. The problem of increasing molecular cohesion by means of a strong surface tension so that the mercury will always move as a continuous mass and not adhere to the walls of the container has been solved by using a circular container of which one face wall is spherically curved.*

simplifying the construction of others, while at the same time increasing the efficiency.

Other liquids than mercury may be adopted to act as the controlling element without departing from the principle of this invention.

A New Anti-static Method

A METHOD for reducing static interference in radio receiving by balancing signals received on a loop and a capacitative antenna has been patented (No. 1,556,137), by Roy A. Weagant of New York.

Mr. Weagant has discovered that the most objectionable forms of static impulses seem to behave as though they are due to vertically propagated waves heterogeneously polarized. Knowing that signal waves are horizontally propagated and vertically polarized, he has devised a new method for minimizing static interference.

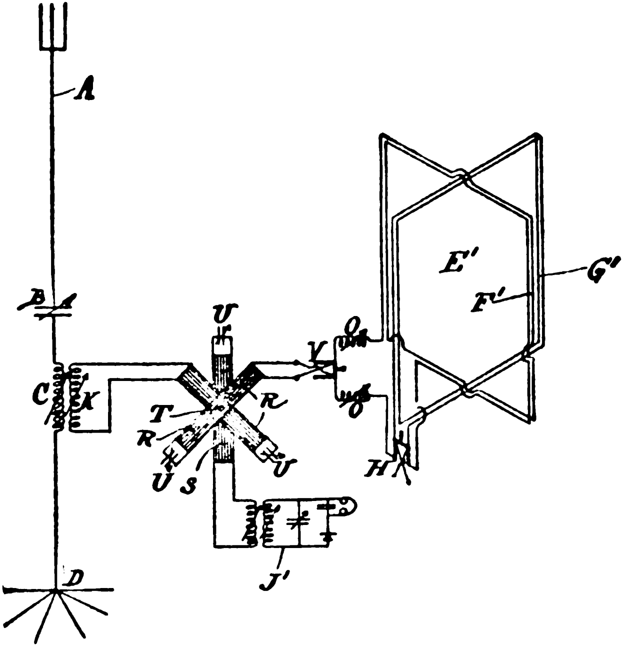
The present invention is based on discoveries made by Mr. Weagant before and also on certain additional facts he has discovered in regard to the properties of different types of aerials, when they are associated in a certain way.

Antennas of different forms draw energy from the static and signal waves in different ways. The phase and direction of currents produced in them are differently affected by the polarization and direction of transmission of these waves. These differences, he finds, can be utilized to at least partially cancel static and retain signals from one-half of the horizon.

It is well known that a vertical open antenna receives horizontally propagated vertically polarized signal waves equally well and with like effects, no matter from what direction they may arrive; it is also known that such an antenna, whether grounded directly or through a counterpoise, will also receive static waves.

On the other hand, a loop antenna or a system of loops is differently affected by the direction of arrival of signal waves, and on purely theoretical grounds Mr. Weagant believes it probable that it is also differently affected by static waves when their direction of polarization changes.

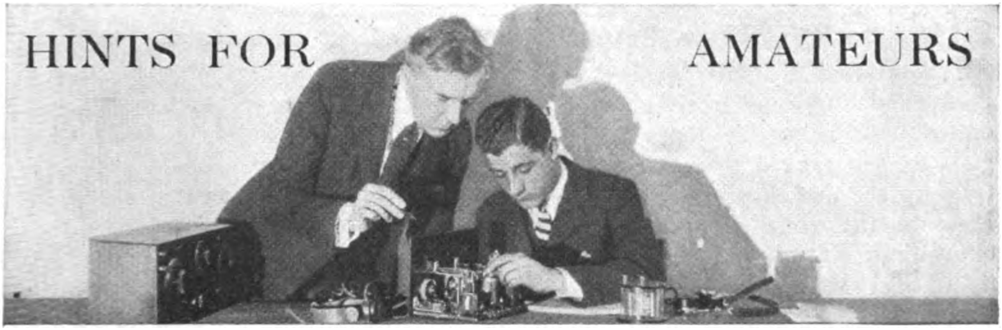
In applying these principles, the inventor also finds that if currents are set up in associated antenna which are largely indifferent to the polarization of vertically propagated waves, so far as reception of energy is concerned, and which are differently affected by the azimuthal direction of horizontally propagated waves, he is enabled to geometrically combine the effects of the antenna currents on a common detector circuit. The result is that at least part of the static currents, and the signals from one-half of the horizon are approximately neutralized, while currents due to signals from the other half of the horizon are retained and more or less effectively added. Thus a most useful method and apparatus is produced for reducing both static and interference effects. A schematic diagram of this method is shown in Figure 7.



WEAGANT'S ANTI-STATIC METHOD

FIGURE 7: *A wiring diagram of a new method of reducing static disturbances by balancing signals received on a loop and a capacitative antenna.*

HINTS FOR AMATEURS



Conducted by Albert G. Craig

The Variable Grid-leak

The use of a variable grid-leak in a regenerative receiver will be found to be a decided improvement in regenerative control over the ordinary fixed type of leak. It will allow the tuning in of more distant stations as well as increased selectivity of the receiver. Try one in your set, if you haven't one now, and notice the difference in results.

Clips for the New AC Tube

The two heater terminals on the AC tube, which are placed at the top and protruding from a small bakelite connection block, do not offer a ready connection to the wires that furnish them with AC current. The manufacturers, however, have now placed on the market a small clip that fits on the tube connections and is equipped with binding post terminals for holding the wire.

Replacing Crystals

Many owners of home-made crystal sets complain that their crystal receiver works very well for a period of three or four weeks and then the volume steadily decreases until the signals are almost inaudible. They ask what the trouble is. The crystals deteriorate with use and should be replaced by new ones whenever the signal strength dies down to a value below which the signal is too weak to be understood. This is the only upkeep necessary with a crystal receiver and it is low, for the crystals cost but a fraction of a dollar.

The Plate Resistance Value for a Resistance-coupled Amplifier

A resistance of 250,000 ohms in the plate circuit of the resistance-coupled amplifier tubes will be found to be the best value to use for maximum amplification. Values higher than this will reduce the plate current to too low value, and values lower than this will cut down the amplification per stage with the standard tubes now in use.

The Tube Rejuvenator

Sometimes the owner of a receiving set finds that the filaments of his tubes seem to give out. This does not mean that they burn out. They light up, but the volume obtained with them in this condition is very small. A thoriated filament tube may become damaged by excessive plate current application or by some other mishap. The original condition may be restored by using one of the tube rejuvenators that has recently been placed on the market. These rejuvenators consist of a transformer with taps for applying an alternating current voltage to the filament. The voltages that should be applied vary in intensity and the application of each voltage should be made for only a certain length of time. These tube rejuvenators have been found to restore at least fifty percent of the tubes that have heretofore been considered worthless.

How to Test Your Batteries

If you find that the quality of reproduction in your receiver is deteriorated, that is, if the reproduction begins to get ragged, look at your batteries to see that they are not exhausted. Measure the voltage of the "B" batteries first. They should register more than 16½ volts for every 22½ volt section. If they do not give a reading above this value, replace them with new batteries. Also, test your "A" battery with a hydrometer and be sure that the reading is above 1,150. If it is lower than this, charge it at once.

After this is done, you will notice that the quality will be improved greatly unless you have some other trouble in the audio-frequency amplifier.

The Most Economical Receiver

For local reception up to ten miles on the headphones, a good selective double-circuit crystal receiver will give really fine results. This type of receiver has practically no operating expense. The only expense incurred would be in replacing the crystals every two or three months. The cost of these crystals is so low as to make this expense negligible.

A Hint for Cleaning the Panel

Never use water for washing the panel or any part of a radio receiver. If the panel gets dirty or greasy, dampen a soft cloth in alcohol and rub it lightly over the surface to be cleaned. This will remove the dirt and grease, and upon drying it off with another clean cloth it will leave a beautiful smooth polish without in any way damaging the apparatus. The alcohol evaporates rapidly.

When You Tighten the Panel

When screwing the panel to a radio set, first be sure that the holes drilled in the bakelite are spaced correctly, so that they will gauge with the center portion of the wood—top, sides and bottom. Do not try to screw the wood screws directly into the wood without first drilling a small hole to give the screw a chance to start properly. Use a small drill of about one-half the diameter of the screw and drill the hole about two-thirds the depth that the screw should go into the wood. This will give you a good, secure fit and will prevent splitting the wood.

How to Test Loose Connections

If you have a loose connection in your set that makes a jarring or rattling sound in the headphones or loudspeaker, it would be well to lift up the lid and investigate each wire to find out which one may be loose. Use a small wooden rod for moving the wires while you have a station tuned in. By pushing the wires with the rod slowly back and forth, you will hear a loud sound when you move the one that is loose. Then you can tighten it at the binding post or solder it fast where it is loose.

Never use a metal screw-driver for this purpose, as you may shortcircuit the "A" and "B" battery connections and blow out all your tubes.

Never fuss around the insides of any radio receiver with a screw-driver when the batteries are connected.

Keep Away from Power Lines

When you install your antenna wires be careful that they do not run over or under any electric wires or cables that may be in the vicinity. Do not place them near any such wires because the wires themselves may carry high-voltage currents, and if they fell on your antenna they might conduct the high voltage currents down to your receiver while you were tuning in. This might subject you to a severe shock. Keep your antenna away from such lines and prevent accidents.

LISTENING IN

PRACTICAL *pointers from experimenters and broadcast listeners. What helpful hints can YOU offer to your fellow fan? Readers are invited to address their letters to the editor of this Department.*

CONDUCTED BY LLOYD JACQUET

How I Avoided Accidental Grounds

I WAS surprised some time ago to see the rheostats in the filament circuits of my five-tube neutrodyne get heated up red hot. After investigation the trouble was traced to an "accidental ground."

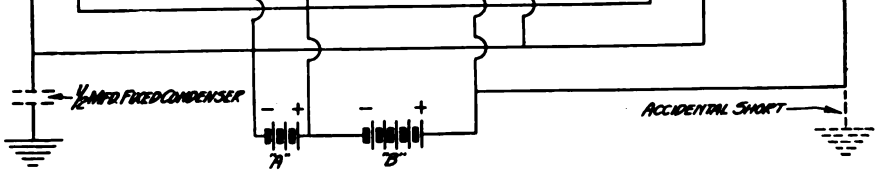
What had happened was that the entire output of the "A" battery had short-circuited through the portion of the rheostats in use, and as this device is made to carry only a small amount of current it was badly burnt.

The ground connection of the receiver is usually placed in the negative filament lead of the vacuum tube. The rheostat then is in the negative lead and in series with the "A" battery. Then the negative side of the "B" battery is connected to the positive terminal of the "A" battery.

Now, if some misconnection is made, say in the "B" battery circuit, the "A" battery discharges through the rheostat.

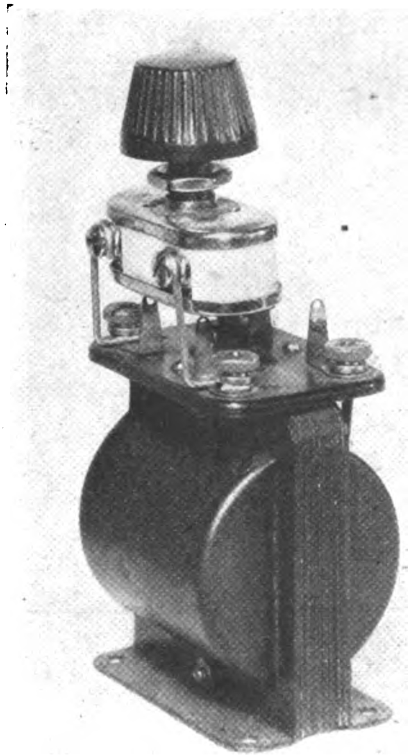
The only way to prevent this trouble is to obviate any possibility of an accidental ground. This can be done cheaply and conveniently by placing a large capacity fixed condenser of say a one microfarad capacity in series with the ground lead. It will not interfere with ordinary reception, and will prevent any trouble of this sort.

—FRANCIS PARKER



A LARGE FIXED CONDENSER INSERTED IN THE GROUND LEAD

This diagram shows how a condenser may be used to insulate the set from ground, thus preventing short-circuits in case the "B" batteries happen to become grounded or if the "A" battery is being charged.



HOW TO MOUNT THE VARIABLE RESISTANCE

This picture shows how the variable resistor may be mounted directly on the terminals of the transformer.

How I Reduced Interference With a Variable Resistance

SINCE I am located where there is a great deal of interference from electrical devices such as motors, starters, household appliances and other "noise makers," my reception has been marred considerably. I was told that there was no remedy for this except to remove the source of the noise, which is impossible in this case.

In an effort to reduce the trouble so that I might enjoy the programs I hit upon the idea of shunting out the noise.

Following out this idea I shunted a variable high resistance unit across the primary of the last radio-frequency amplifying transformer of my five-tube, tuned-radio-frequency receiver. I found that a resistance of from 5000 to 3000 ohms could be used.

The lower the resistance used, the less noise there will be, but the volume of reception will also be cut down to a considerable extent. However I found that with a variable Bradley-stat the right resistance value to give pleasant reception with a suitable volume can be readily obtained.

It is easy to fasten this resistance to the transformer, and practically no alteration need be made to the set itself. The resistance is merely connected to the two terminals of the primary of the transformer.

My theory is that the resistance passes the noises, (as well as a certain amount of energy), and prevents them from going through the transformer winding and into the loudspeaker circuit.

—PAUL E. LAMAR

Is Your Antenna Short Circuited?

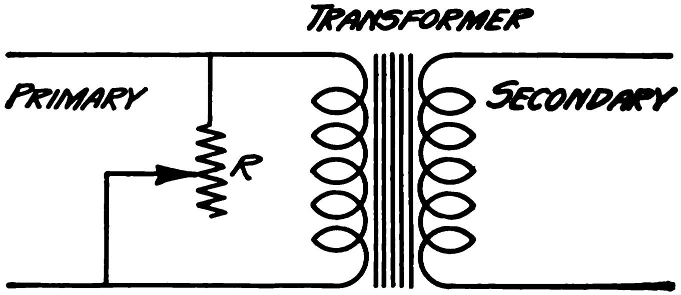
ANTENNAS that are partially grounded are often an unsuspected cause of trouble to radio fans.

I was bothered for an entire month with a peculiar condition of reception in which signals went on or off without the least warning. At first, thinking it was a case of poor batteries, or defective tubes, or possibly a loose connection in the set, I checked up on all those details but there was no improvement.

Finally during a wind storm, I discovered that the trouble was due to the branch of a tree, against which my single wire antenna was rubbing, thus grounding itself.

However I wanted to make sure that I had a defective circuit in the antenna.

By means of a pair of telephone receivers, and a battery, I was quickly able to determine



THE CIRCUIT WITH THE RESISTOR IN PLACE

This diagramatic sketch shows the connections for hooking the variable resistance in shunt to the primary of the audio-frequency transformer for cutting down extraneous noises.

HOW TO ATTACH THE BLUEPRINT TO THE PANEL

A convenient method for drilling the holes in the correct places in the panel is to paste a blueprint in correct position on the panel and spot the holes directly from the markings on the blueprint. When the drilling is done, the paper may be loosened and taken off the panel.

that it was grounded. The phones were connected in series with the antenna and the battery and ground. Each time the tip of the phones was touched on the battery, a loud click was heard. When the branch was blown away from the antenna wire, the click was very faint.

By removing the aerial at a greater angle I was able to make it clear the tree, and do away with my shortcircuited aerial and poor reception.

—Milton Brandt

How I Avoided Mistakes by Drilling Panels

IT has been my experience to spoil many good panels by carelessly laying out the drilling, or by making mistakes in measurement that disfigured the whole set.

In order to guard against these costly errors I have developed an idea which seems so elementary and yet is so effective that I am passing it along to other radio builders for their benefit.

Most construction articles in good magazines include a detailed drawing of the panel layout. Because of the small amount of space available this cannot be given in full size. Get a sheet of drawing paper, or even thin drawing "skin," and lay out the panel as shown in the magazine illustration, but in full size.* Check over everything carefully and then secure the piece of insulating material that is to make up the panel proper.

This material should be secured cut exactly to size. Its best surface is selected, and a light coat of shellac is quickly applied. On top of this lay the full size drawing or a blue print, dimensions upwards, and press down firmly with a board padded with a cloth or newspapers. Guard against the drawing sheet from slipping. By comparing the edges of the paper with those of the panel, this can be carefully watched.

The shellac acts as an excellent glue and will hold the drawing on the surface tightly for the drilling. This should not be attempted, of course, before every hole is properly centerpunched. By marking on the drawing the size of drills needed for the various holes, the work can be quickly and efficiently done.

To remove the drawing, just moisten it and peel it off. The extra shellac on the panel surface can be quickly removed by means of a rag dipped in alcohol.

In this way, you will never make a mistake in panel drilling.

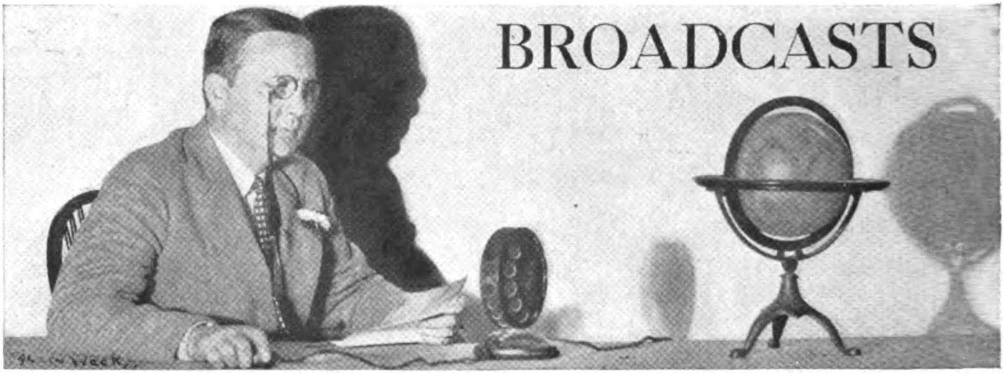
—Henry D. Waller

---

* Popular Radio blue prints may be used in place of the drawings as they are exactly full size.

¶ *What little kinks have YOU discovered that are of interest and value to your fellow fans? Write and tell the editor of this department about them—and enclose illustrations if they are needed.*

BROADCASTS



CONDUCTED BY J. ANDREW WHITE

In this department the Dean of Broadcasters—whose voice is known to millions of broadcast listeners—records items of interest and value to all radio fans everywhere.

The Warfare Between Churchmen and Scientists

THE Very Reverend William Ralph Inge, dean of St. Paul's, London, exploded a theological bombshell it appears by the statement made in a recent sensational article in which he declared that Christianity and science are still at war. His declaration that the church must face the facts of science is echoed in a renewed discussion of the subject prominently before all Christian churches now. Dean Inge declares there is very serious conflict between Christianity and science and that churchmen who declare otherwise either are thoughtless or are wilfully shutting their eyes.

* * *

Help Summoned by "Live Radio"

THROUGH carrier current, a development of radio, communication was maintained with the outside world when a cloudburst and flood destroyed railroad, telegraph and telephone lines at Wenatchee, Wash. For several days the only messages reaching or leaving Wenatchee were transmitted over the high-power electric lines of the Puget Sound Power and Light Company which were recently installed over the mountains to Seattle. The apparatus used is similar to a radio outfit but instead of radiating waves through space in all directions the voice currents are kept concentrated about the power lines, thus insuring privacy and direction for the communications.

* * *

Is Radio Changing Our Taste in Music?

THAT Beethoven was born only four years ago for many of us, with our first acquisition of radio sets, is the interesting angle from which the uplift in musical taste and appreciation is viewed by Percy A. Scholes, widely known musical critic of the British Broadcasting Company, who recently left London for a tour of America. He looks upon the introduction of broadcasting as the greatest event in the history of the art of music and is unreserved in his congratulations to America for developing this activity. Less than eighteen months ago, he says, English radio enthusiasts were protesting that Beethoven, Bach and Wagner were acceptable only to "highbrows who like to swank about their superior tastes," but these attacks have given way to admiration for the works of classical composers, music that has artistic impulse. This further prediction is added: "Give listeners plenty of fine music and they will learn to like it; our British experience is sure to be the American experience."

* * *

What the "Whistling" Form of Interference Really Is

THAT fairly constant and annoying whistle which receivers pick up when the dials are set at a certain point seems to be a source of some misunderstanding among many novices. It is a form of interference set up when two high-powered broadcasting stations are too close together geographically, although they may be wide apart in wavelength or frequency. Radio Supervisor E. A. Beane, of the Chicago District, reports tests wherein he discovered that two stations, one operating on 560 kilocycles and the other on 1,200 kilocycles, produced a beat note frequency of 640 kilocycles, or the difference between the frequencies at which the two oscillators were functioning. Another frequency equal to their sum is also created, under the well known principle of heterodyning. It appears, however, that the third wave, or frequency, has a field strength considerably lower than the originals, and is reported to be objectionable for a distance of only five miles when the two stations are using 500 watts of power, and twenty miles when 5,000 watts power is used. Some time ago the Navy took this phenomena into consideration and decided to use frequencies ending in 5; any new frequency created by beat notes is therefore not an assigned frequency, or wavelength, and cannot interfere with regular channels, since their sum or difference would necessarily be a frequency ending in O. A reassignment by the Department of Commerce to prevent this form of "beat" interference may be undertaken on this basis—that is, increasing all assignments by 5 kilocycles, or reducing them that much.

* * *

$800 in Prizes for Short Radio Dramas

To stimulate the writing of plays especially designed for broadcasting, station WLS of Chicago is sponsoring a "national radio play contest" in cooperation with the Drama League of America. To be eligible for this contest plays must be written "as though they were to be produced for the blind" with every exit and entrance indicated and with as many explanatory sounds (such as rain, automobiles and telephone bells) as possible, to take the place of a background. And they must be one-act plays that take from eighteen to twenty-five minutes to produce and with no more than five characters. Prizes of $500, $200 and $100 are offered for the three best plays submitted.

* * *

A New List of Foreign Stations

AVAILABLE to those who would like to have it is a supplementary list of foreign broadcasting stations recently issued by the Department of Commerce; included are six stations in Denmark, eighteen in France, fourteen in Sweden, eight in Switzerland, two in Jugoslavia, six in Argentina, four in Chile, one each in Poland, Peru, Hongkong, Ceylon and Morocco; sixteen in Japan, nineteen in Australia, two in Canary Islands, and two in Tunis, Tunisia.

* * *

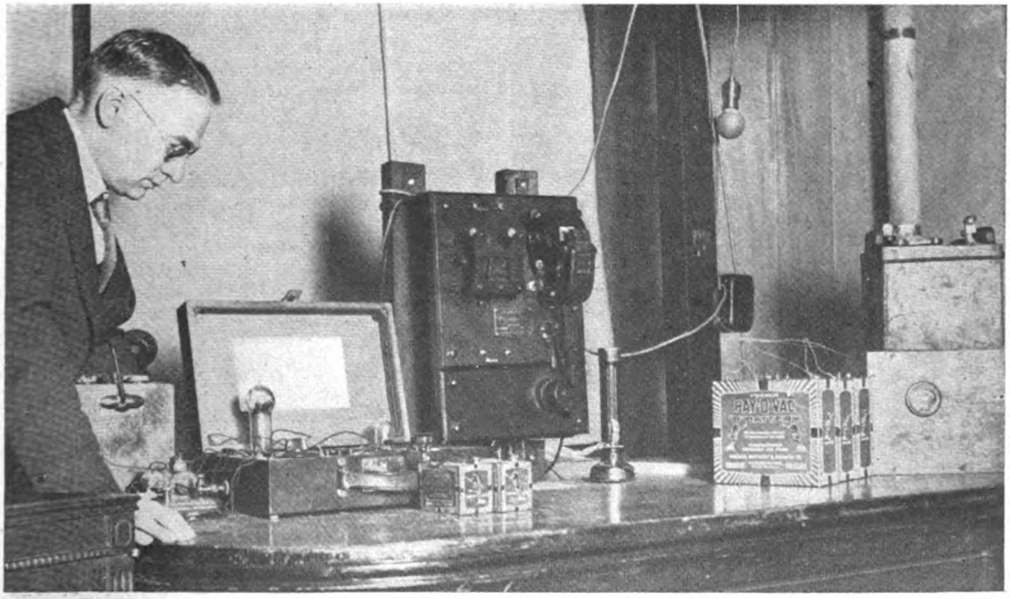
Small Receivers for Japanese Fans

MANUFACTURE of small radio sets was recently undertaken in Japan but none have yet been placed on the market. It is expected that this field will be entered actively before long, following the announcement of the merger of the Nipponphone Phonograph Company, Tokyo, and the Tokyo Phonograph Company.

* * *

More Radio, More Milk

FROM Strasbourg comes word that Rhineland dairymen have discovered that music not only soothes the cow, but induces her to increase her milk supply. It is asserted that in recent tests when a phonograph was placed within hearing of the placid German cow, appreciation of the musical accompaniment to the absorption of bran mash resulted in increases of 6½ percent in the quantity of milk given by bossie. It has not yet been determined, however, whether repetition of a limited repetoire of numbers would result in the contempt for the musical aid induced by familiarity, but so as to take no chances it is now proposed to install radio loudspeakers in the barns that the cows may have a bit more of variety in their programs.



Kadel & Herbert

A TUBE THAT GOES TO WORK AT THE WAVE OF YOUR HAND

The large tube in the portable radio set at the left is a new development of the radio vacuum tube that is energized into activity by the slightest shadow that falls upon it. In a recent demonstration by its inventor, Mr. V. K. Zworykin, a washing machine was started by waving a hand in front of the tube.

Transatlantic Movies by Radio

A NEW machine for the almost instantaneous transmission of photographs or motion pictures by radio, known as the "radioscope," is shortly to be subjected to transatlantic tests, according to an announcement from the Telefunken Company of Berlin. A paper surface ten centimeters square bearing either writing or a photograph can be transmitted in a few seconds, it is claimed, and ultimately transmission will become instantaneous. Lessened cost of operation due to speed is the inherent difference between the German device and previous instruments of similar type, according to the announcements which credit the invention to Dr. Carolus of the University of Leipsic. Confirmation of the report that the tests would be held with the co-operation of the Radio Corporation of America could not be obtained through the New York officials of that company, who also denied knowledge of the invention which, it was said, had no connection with the several successful tests of radio picture transmission between New York and London.

* * *

The New "Panatrope" Instrument

BEFORE a distinguished audience in which New York society was represented by such names as Mrs. Vincent Astor, Clarence H. Mackay and Otto H. Kahn and with the field of music represented by Leopold Auer, Frank Damrosch and Henry Hadley, among others, a new musical instrument which utilizes the electrical principle for the reproduction of sound was presented recently at Aeolian Hall, New York. Westinghouse, General Electric, Brunswick and Radio Corporation collaborated in the development of the instrument of which it was said that it was not a new or improved phonograph, but a milestone achievement in the union of electricity with music, based upon recording and reproduction by electricity. Dr. Alfred N. Goldsmith, speaking through the instrument from Washington, described the operation as one which superseded the mechanical method of phonograph recording. He explained that the singer stands in front of a device which is analogous to the finest broadcasting microphones and the electrical currents therein set up are amplified by vacuum tubes like those in a receiving set, and that the final output of these tubes operates a most precise cutting tool which makes the master record. The horn is absent, he said, and the energy for cutting the record no longer comes from the voice of the singer, but from electric generators or batteries feeding the vacuum tubes. On the reproduction end, no sound box is used and no horn. Instead of the needle resting in the conventional phonograph groove vibrating a sound box diaphragm it actuates a tiny strip of metal in what is known as the electrical pick-up, a small device enclosing the needle holder. Through these vibrations electrical currents are produced which pass through a powerful vacuum tube amplifier, operated from alternating current from an ordinary electric light socket, and the amplified output is fed into a loudspeaker of the free-edge cone type.

Kadel & Herbert

A CLOSE-UP OF THE NEW "SHADOW" TUBE

The new photo-electric cell is compared by its inventor, Mr. V. K. Zworykin, with one of the standard 199 type. By placing an obstruction in the way of the light rays falling upon the uncoated portion of the bulb at the top, it is possible to operate relays which will control power.

* * *

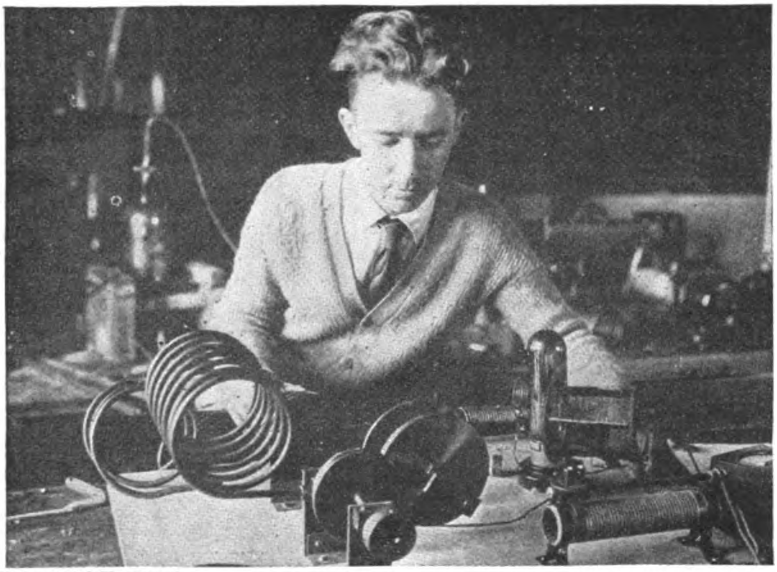
The Don Dons the Headphones

SPAIN continues to show additional progress in radio with another broadcasting station to be erected at Malaga, the first in that section of the country. Static interference has made the reception poor from foreign stations, and the Malaga fans are celebrating the advent of the new local station to a point where it is reported that radio receiver sales are reaching boom proportions.

* * *

The First Receiver to Be Bequeathed

FOR the first time on record, in New York at least, a radio set has been bequeathed by its owner by will and testament. The official files contain mention of practically everything imaginable, from fountain pens to millions of dollars in legacies, but it was a new one on the Surrogate's Court when the will of Edward F. Gordon was filed and it was shown that a beneficiary was to receive the radio set prized by the late departed. Gustave W. Fuerth, of Newark, was the friend named to enjoy that distinction.



Underwood & Underwood

A "CONFIDENTIAL TRANSMITTER"

By means of this short-wave transmitter which he has invented W. W. Salisbury hopes to carry on conversations by radio as privately as by telephone. By calculating the length of the transmitted waves and concentrating them in a narrow shaft with a reflector, he expects to direct them accurately.

How Radio Helps the Small College

JUST as the new and open style of football created by the rules committee brought colleges and universities into national prominence in sections of the country which had not previously known of their existence, so may radio publicize institutions of learning into country-wide fame such as their founders never hoped for. This possibility is indicated in the recent formation of an association of professors representing the educators who are broadcasting, headed by a president who hails from Carleton College, wherever that may be. Other member institutions are Beloit, Nebraska Wesleyan, Wisconsin, Kansas, Michigan, Ohio State and Iowa State.

* * *

The "Song of the Atom"

EVER since radio research brought about the division of the atom, increasing wonders have pyramided so rapidly that it will hardly occasion any surprise to learn that now the radio audience has been introduced to the song of the electron. The demonstration occurred during a broadcast talk by Dr. Peter I. Wold, professor of physics at Union College. A photo-electric cell was connected to the broadcast circuit of WGY and a disc with many rows of perforations was placed between the cell and a light source. The photo-electric cell is coated on its inside surface with metal potassium which is very sensitive to light. At the center of the cell is a plate of tungsten. When light falls on the potassium coating electrons are given off and travel to the tungsten plate, thus constituting a current. By means of a motor the disc with circular rows of holes was rotated between the light and the cell. When the disc was revolved slowly a low pitched note was given off, rising gradually as the speed of the disc increased. For the construction of an organ, the ingenious experimenter would need only to have rotating discs with rows of holes of the right numbers, which could be uncovered by small slides operated from a keyboard, and the loudness of the notes could be controlled by regulating the brightness of the lamp.

* * *

A High Power Station for Bavaria

FURTHER word has been received that finally a real high-power broadcasting station will soon start operating in Bavaria. It is located in Herzogstrand, to be exact, and providing it is found feasible to satisfactorily modulate speech and music as much as fifty kilowatts of power will be employed for broadcasting purposes. The construction of the station has been in progress for some time, and it is now said to be nearing completion, with an antenna stretched between two mountain peaks.

* * *

How Many Broadcast Listeners Are There?

ACCORDING to the figures recently compiled by the British Broadcasting Company there are 10,000,000 listeners on the British Isles alone; of this number 8,500,000 own the "very simplest receiving apparatus."

"Radio Scouts"

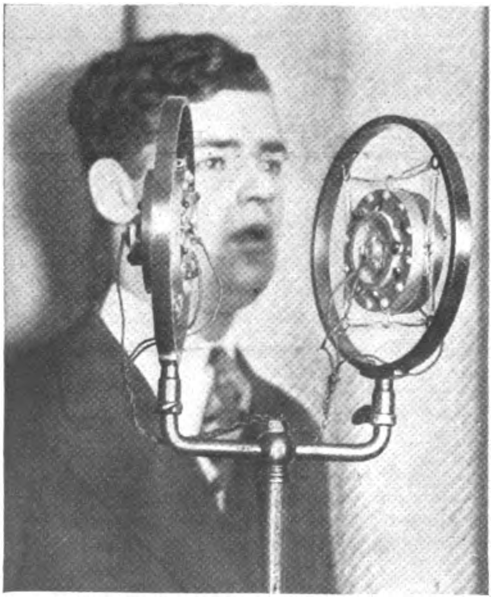
An interesting experiment has been conducted by the Boy Scouts of America in co-operation with station KDKA, at Pittsburgh, Pa., for the benefit of boys who live on farms so far out in the country that they cannot attend troop meetings. Once a week a snappy troop meeting program has been broadcast, including songs, bugle calls, the Scout Oath and Law, addresses, cheers and games. Boys who listen in are invited to enroll. They are known as "Radio Scouts."

* * *

What Was Accomplished at the Radio Conference

Regardless of the informal nature of the Fourth Annual Radio Conference, held in Washington recently upon the call of Secretary of Commerce Herbert Hoover, it cannot be denied that it faced every one of the issues confronting the broadcasting situation squarely and decisively.

One need only tune to the higher frequencies with a sensitive receiver in any part of the country to realize that there is something wrong which must be remedied if broadcasting is to prosper. The ether today is an overcrowded bedlam with interfering carrier waves and radiating receivers. Fortunately, the upper part of the broadcast band has been reserved for high grade stations, each operating upon its exclusive channel, reducing heterodyning of carrier waves on wavelengths above 280 meters to a minimum.



Fotograms

A NOVEL TYPE OF MICROPHONE

These new double-button microphones have been installed as part of the equipment of New York's newest station, WHAP. Each microphone is mounted upon a pivot so that it may be turned towards or away from the performer to vary the volume of sound transmitted.

But even this reserved domain has been threatened by the clamor of scores and hundreds of applicants for wavelengths who would encroach themselves upon the long suffering listener. Up to this time, licenses have been granted to broadcasting stations on the theory that the ether is free to all those who would use it. As a consequence, we are now faced with a superabundance of stations and only by the adoption of a new basis for the issuance of licenses can we avert a chaotic condition of the ether.

In dealing with this problem, the conference went on record as opposing the granting of a single additional license until there shall be a substantial reduction in the number of broadcasting stations now operating. It further recommended that hereafter the basis for issuing a license shall be service to the listener. The license shall be regarded as permission to trespass upon the sacred domain of public property, extended only to those who render a public service by using one of the few available paths in the ether. It shall not be used for selfish purposes, such as direct advertising and the hawking of wares. Only the good-will type of educational or entertainment program may be sponsored by commercial organizations. After a definite date the manufacture of radiating receivers, the all too-prevalent disturbers on the highway of the ether, shall be discontinued.

It is true that these and other recommendations of the Conference are simply the expressions of opinion of a body of qualified experts, representing the broadcast listeners, newspapers conducting radio sections, radio magazines, broadcasting stations, receiving set manufacturers and operating radio telegraph companies. Many of their recommendations the Secretary of Commerce is not empowered to carry out. Certainly an informal conference is not endowed with authority to delegate him powers which amount literally to those of a dictator of the ether. Nevertheless, the advice of the conference, as embodied in its reports, will undoubtedly be a potent influence in shaping legislation which will make possible the legal enforcement of most of its recommendations.

—Edgar H. Felix

* * *

A Radio Set for Every Boy Scout Troop

A recent questionnaire sent to the 800,000 Boy Scouts throughout the country revealed that 95 percent of them either own radios—or want to. In Boy Scout camps the use of the radio is practically universal; a Boy Scout troop without a radio outfit is a rare exception. Furthermore, this may be applicable even to winter camps, as indicated by 600 Boy Scouts who last winter spent their holidays camping in the Interstate Park of New York and New Jersey. Radio sets were almost as thick as snowshoes and skis.

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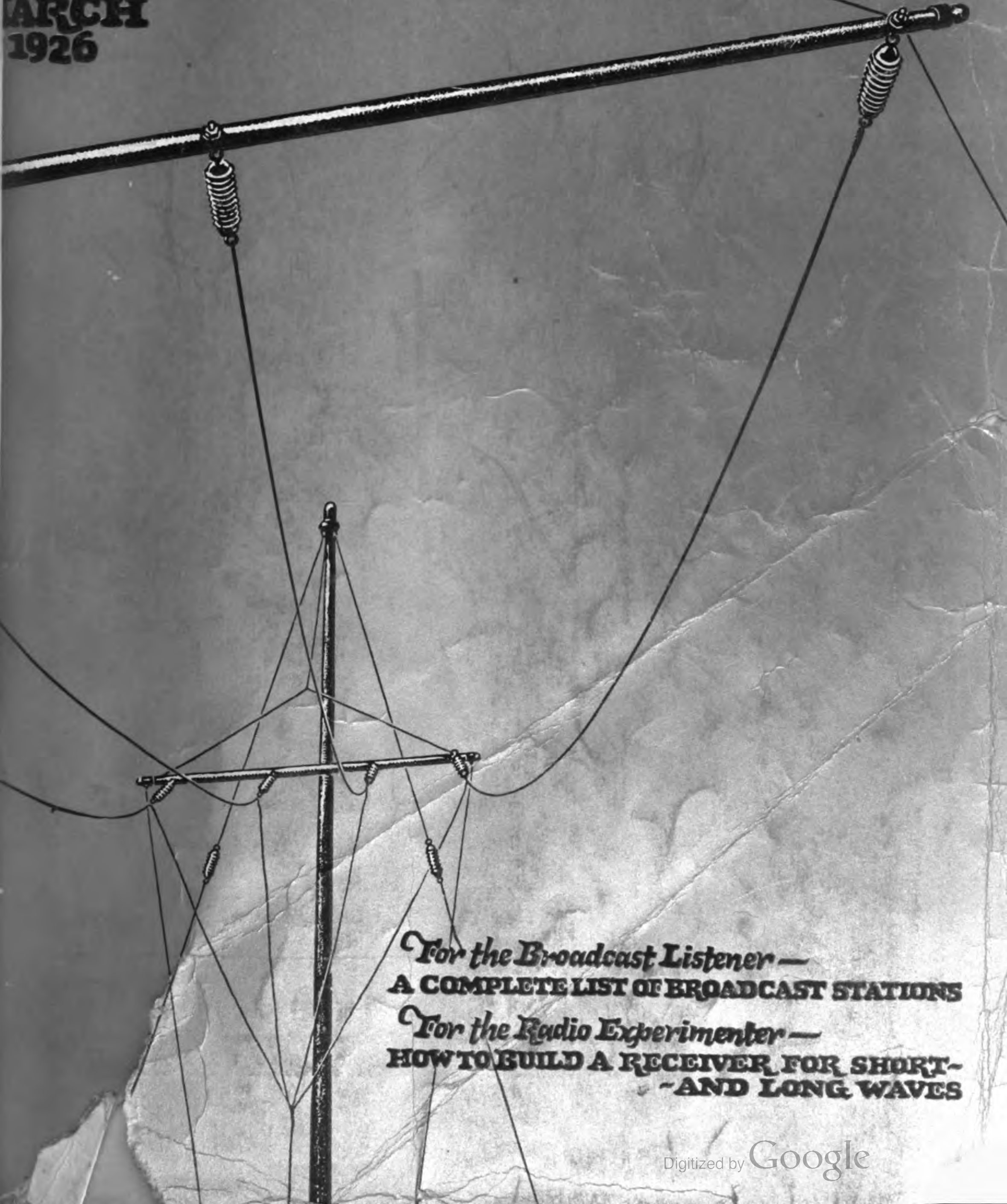


For the Broadcast Listener—

A COMPLETE LIST OF BROADCAST STATIONS

For the Radio Experimenter—

HOW TO BUILD A RECEIVER FOR SHORT- -AND LONG WAVES

130,000 times better

One of the great steps forward in the development of the Radiotron was the evolution of the X-L filament.

When you tune in to clear reception, do you know that a stream of electrons leaping from a glowing filament is the current which, translated into sound, you hear as a fine symphony, a jazz orchestra, a clever story?

The more electrons thrown off at a given temperature, the longer the tube lasts, and the longer the batteries last. The X-L filament in Radiotrons UV-199 and UV-201-A throws off, at operating temperature, 130,000 times as many electrons as an ordinary tungsten filament. In one sense, therefore, the X-L filament is 130,000 times better!

And this filament means stability, too—and silent operation. And it keeps its efficiency practically to the end of its life.

Watch for the RCA mark on every tube you buy, and know that you have the latest, most perfected tube, as well as the most accurately made.

Radiotron UV-199

is the standard tube for dry battery sets. UX-199 is exactly like it, but has a new base.

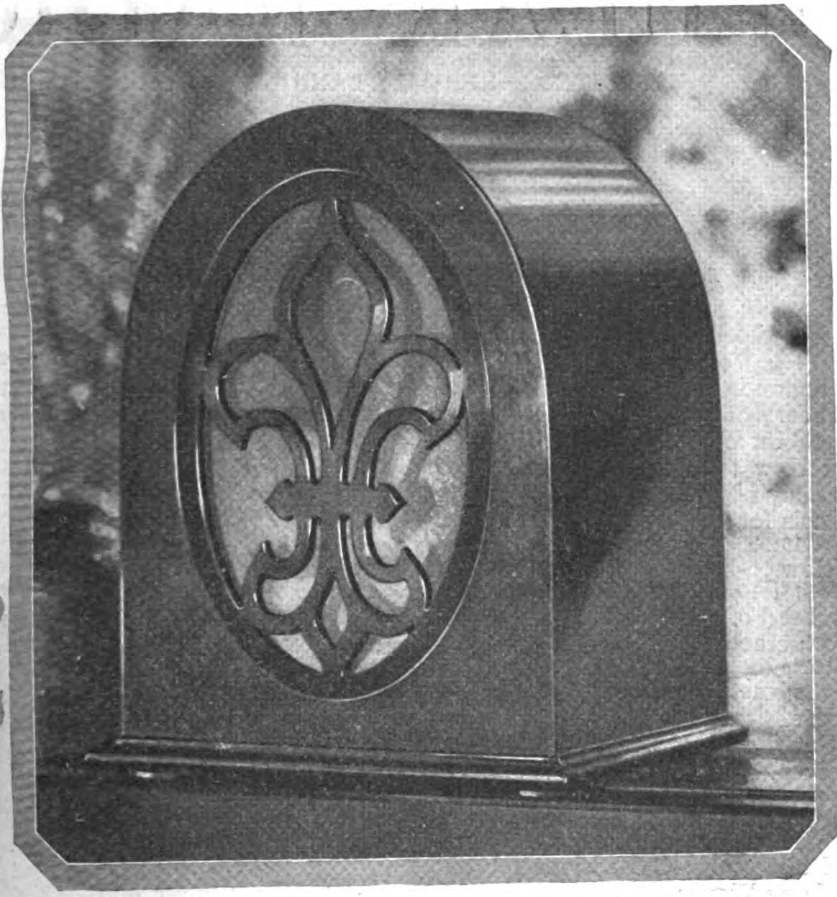
Radiotron UV-201-A

is the standard tube for storage battery sets. UX-201-A is exactly like it, but has a new base.

RADIO CORPORATION OF AMERICA
New York Chicago San Francisco

RCA Radiotron

MADE BY THE MAKERS OF RADIOLAS



Brandes Cone Speaker

A truly decorative bit of furniture concealing a speaker of remarkable qualities—faithful, natural. Low and high notes gain new charm. Greater volume. A de luxe product, the result of 17 years of research and experience in radio acoustics.

Brandes

experts in radio acoustics since 1908.

POPULAR RADIO

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"EVERY *year of our work with radio has brought a greater appreciation that it is one of the most progressive forces ever known. To observe, to announce and to explain this progress so that mankind can benefit to the fullest degree from it is a notable service.* POPULAR RADIO *is performing this great task with distinction.*"

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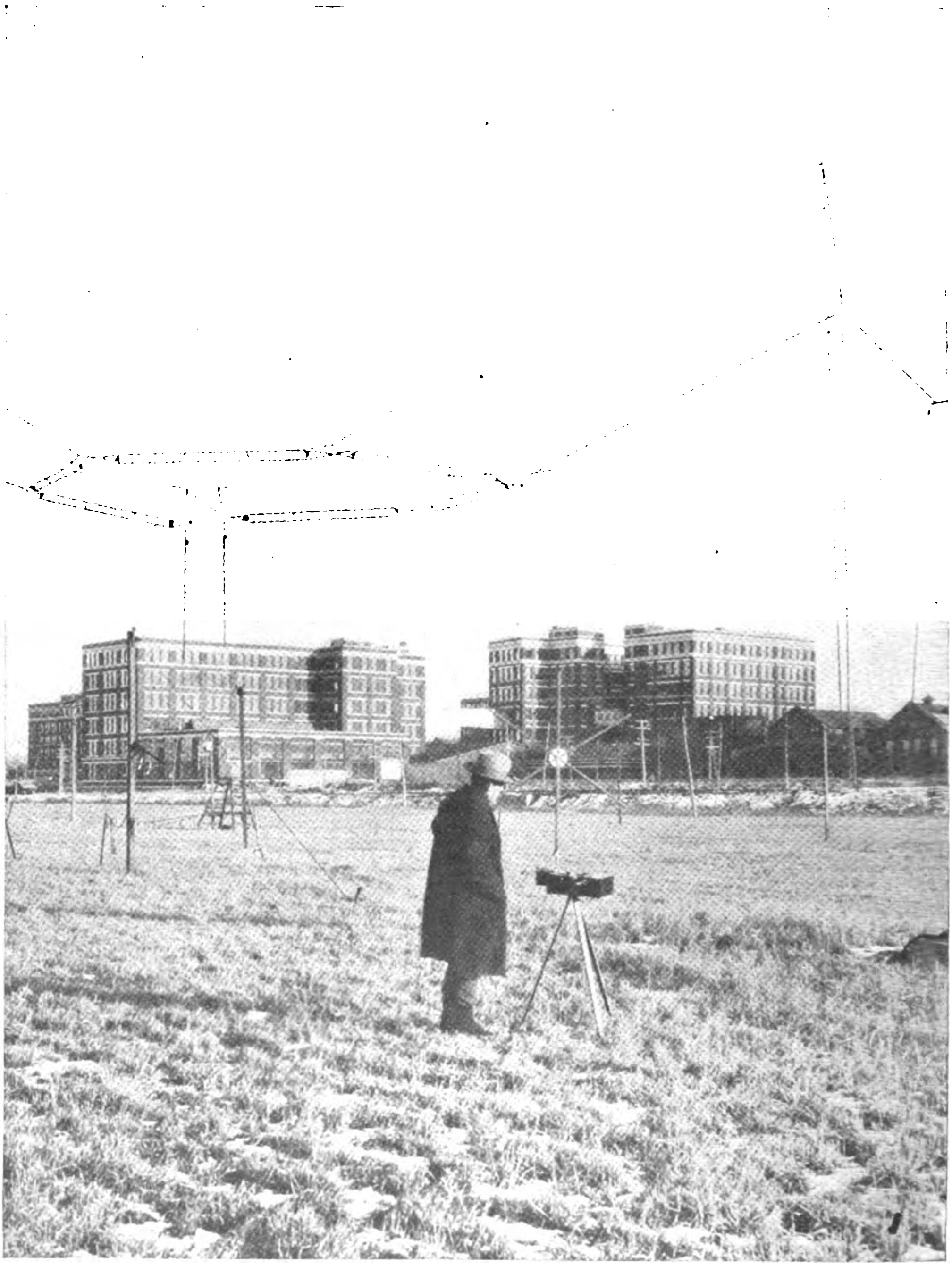


From a photograph made for POPULAR RADIO

A Phenomenon in Radio Reception That Has Led to a New Theory of Wave Transmission

Here is an ordinary vertical loop direction-finder that is tuning in at the ***maximum amplitude*** *the signals which are being transmitted from the* ***horizontal*** *wave* ***antenna shown in the*** *background—despite the fact that the loop is* AT RIGHT ANGLES *to the* ***direction of transmission.***

Popular Radio

VOLUME IX MARCH, 1926 NUMBER 3

A NEW THEORY OF

WAVE TRANSMISSION

All of the theories of "radio waves" heretofore propounded fail to explain certain radio phenomena. In the course of his researches into these mysteries in his extensive field laboratory, the author of this article—who is one of the world's foremost scientists—developed a new theory that he has illustrated with a simple and novel mechanical model. This new theory, which accounts for fading and the erroneous results met with in direction-finding and which throws light on the little-understood "horizontal radio wave," is put forth for the first time in this article that has been prepared exclusively for POPULAR RADIO.

By E. F. W. ALEXANDERSON

THE earliest radio literature describing the experiments of Hertz makes it plain that even at that date the possibility of polarization of radio waves was realized by this pioneer discoverer. Then this subject fell into complete neglect so far as practical radio technique is concerned. When it again came to our attention recently during our research work on short waves it was through an accident. And it came as unexpectedly as a new discovery.

What we are now trying to do is to formulate a conception of what the radio wave consists of and how it travels. We have too long been satisfied with mathematical symbols that have no definite physical meaning. This has limited our vision in understanding wave propagation and some of the most important radio phenomena remain unexplained.

We are therefore approaching the subject from two angles. One is the classical theory of light radiation in the ether; the other is the electromagnetic theory as we know it in electrical engineering.

Both of these theories have their difficulties and their shortcomings.

The only positive knowledge we have of electricity is the electronic theory. We know that the electron is the smallest element of matter. We know its mass, its electric charge and we know how fast it travels. But we do not know what magnetism really is. As a matter of fact we have good reason to believe that *there is no distinct force that can be called a magnetic field* and *there is no ether in the old sense.** If there were an ether what is the relation between the electron and the ether and between the ether and magnetism.

---

* See "There Are No Ether Waves" by the late Dr. Charles P. Steinmetz. POPULAR RADIO for July, 1922, pages 161-166.

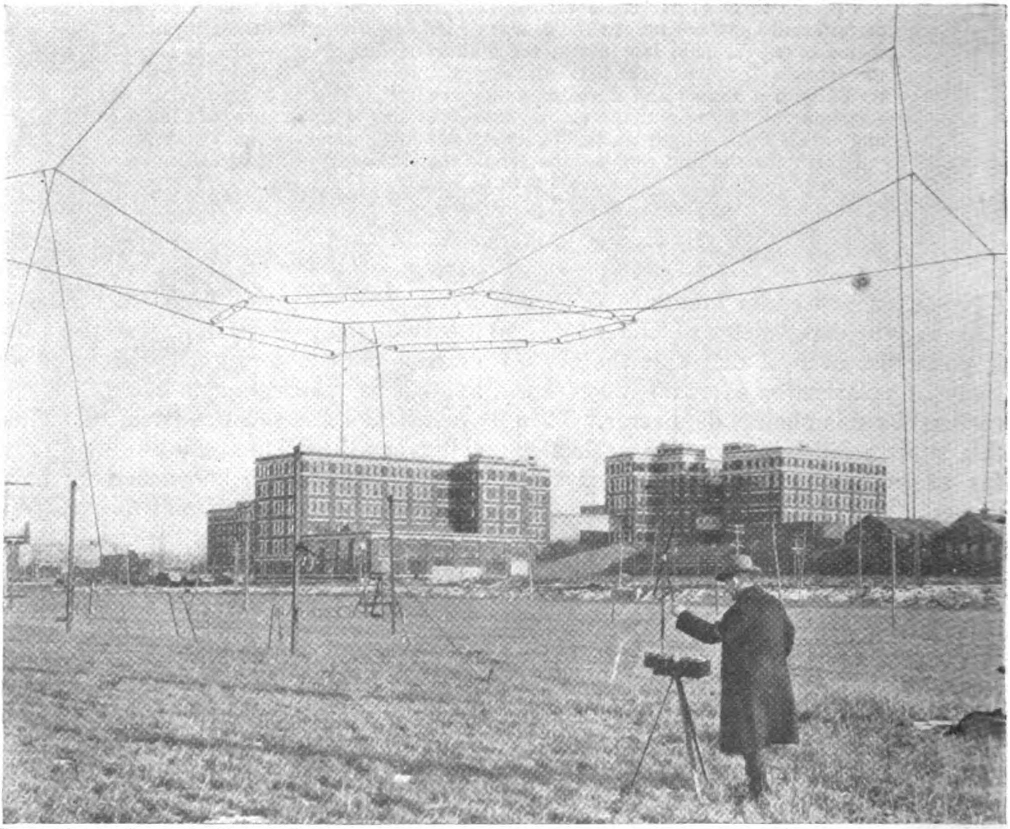
The best picture we can form is to assume that each electron has its own ether attached to it. But why call this medium ether?

Dr. Michael I. Pupin has very appropriately said "why not just call it electricity?" This explanation was given by him in an inspiring lecture delivered in Schenectady to the memory of Dr. Steinmetz. According to this new theory a complete electron consists of a nucleus and an aurora of electricity extending through the universe. If a nucleus vibrates, the aurora tries to follow; but it cannot follow immediately, so the motion progresses in the form of waves in the electric medium. Thus the relativity of light velocities is easy to understand because each source of light carries with it its own track on which it travels.

This electric medium is material; it has mass and elasticity. We can thus form a mechanical conception of wave motion. But what, then, is magnetism?

The answer is, it is simply the velocity or kinetic energy of the electric medium. This sounds reasonable enough, but how about a solenoid magnet?

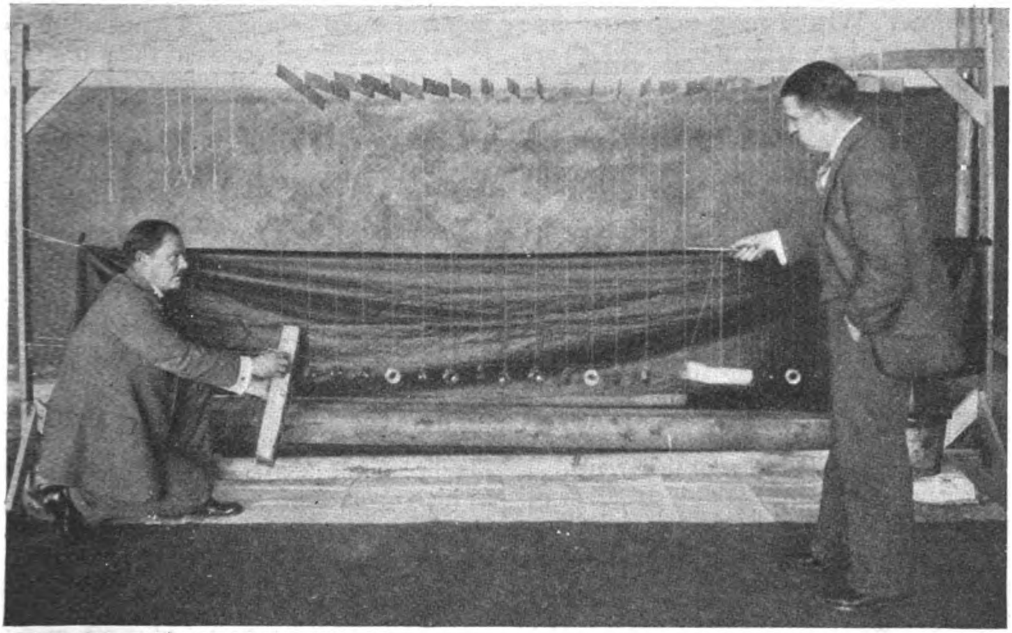
The electrons circulate around in the coil and carry with them the electric medium like a flywheel. When the current is constant, the flywheel runs at a constant speed and consumes no energy except the frictional losses which may be



From a photograph made for POPULAR RADIO

A PHENOMENON IN RECEPTION THAT IS NOT EXPLAINED BY FORMER THEORIES

The operator of the vertical-loop direction-finder here has the loop pointed dirtctly at the transmitting antenna. In this position he would normally get a maximum deflection on the galvanometer that is incorporated in the receiver in the small box mounted on the tripod, yet the meter registers zero.



From a photograph made for POPULAR RADIO

AN EXPLANATION OF "FADING" ON A MECHANICAL MODEL

The model consists of balanced weights hung on strings that are fastened to individual rocker arms; they are tied together by rubber bands in a horizontal direction, to reproduce the field stresses in the wave. At the left Mr. Alexanderson is shown about to start the weights into a wave motion for demonstrating to the Technical Editor of POPULAR RADIO, *by means of a paper weight tied to a string and running over a small glass rod held by the visitor, that at certain points there will be no indication of wave motion by the paper weight detector. This is a mechanical analogy which demonstrates the twisting plane of polarization and also a certain kind of radius.*

said to be the resistance losses in the copper wire. But when we start it and stop it we have to deal with the kinetic energy and we know that inductance has all the characteristics of kinetic energy. Furthermore, if we now run the flywheel back and forth rapidly, by reversing the current, the mass of the distant portions cannot follow immediately and elastic strains are set up in the medium which therefore carries away energy in the form of wave motion. The elastic forces are electromotive forces. The magnetic field is velocity.

This mechanical analysis can be carried still further. Thus a change in magnetic field may be said to be a change of velocity of the medium. But change in velocity is acceleration and is accompanied by forces of mass reaction (inertia). These mass reactions are equal to the elastic forces that produce acceleration. Our old magnetic theory tells us that a change of magnetic field produces an electromotive force and our mechanical theory of the electric medium tells us that the elastic electromotive force, acting upon the mass, produces changes of velocity which are equivalent to changes of magnetism.

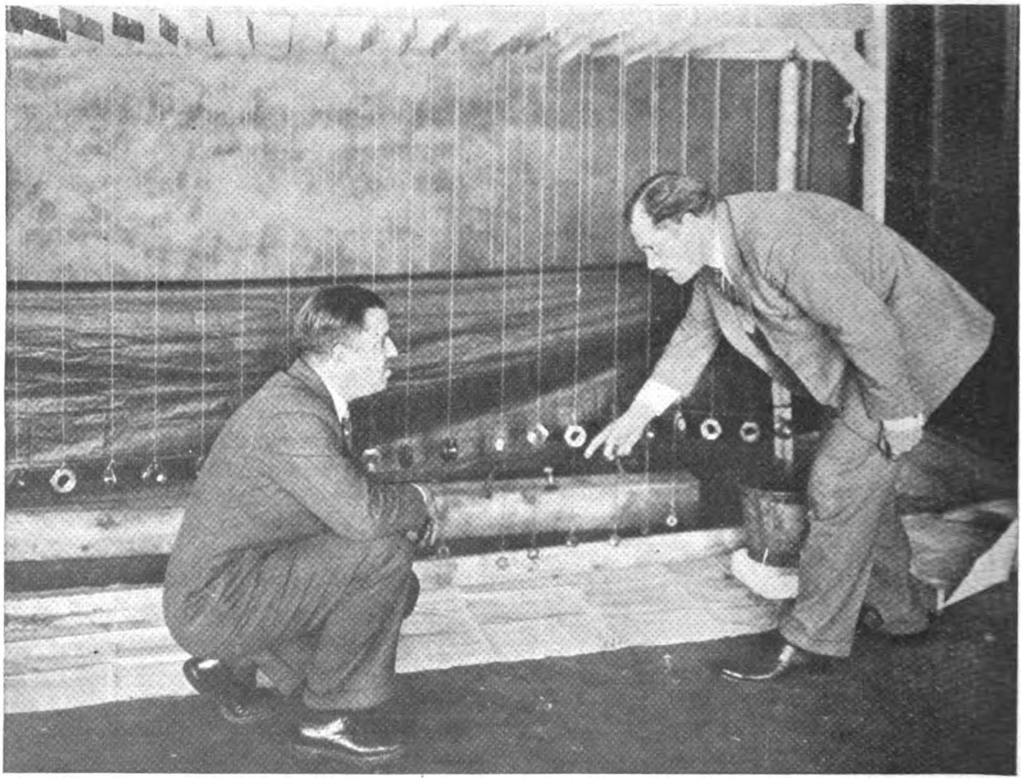
So, you see, the two theories check and we can afford to forget, for the time being, that there is a magnetic field.

The advantage of this reasoning is that we can express our theory in a mechanical model. For study of more complicated phenomena this is very helpful. Such phenomena as linear or elliptic polarization and change in plane of polarization can thus easily be visualized.

One example of the use of the mechanical model for studying wave propagation is an experiment which was made to study a phenomenon which has been often observed but never before satisfactorily explained. What I refer to are the false indications of a direction finder which are sometimes very pronounced.

The following are some of the factors which we desire to correlate by a logical explanation. It has been known almost since the beginning of transatlantic communication with long waves that measurements of direction of wave propagation with rotating loops show peculiar irregularities at the time of sunset. This phenomenon has become known especially from the work of Dr. L. W. Austin and Dr. A. Hoyt Taylor. The apparent deviation in direction of wave propagation which they reported were at times so great that it was feared that the installation of the Beverage antenna on Long Island might at times be rendered inoperative by these changes in direction of the wave. No such effects were, however, observed. Here it should be noted that the observations which showed these irregularities were made with a loop rotated around a vertical axis, whereas the Beverage antenna is a horizontal wire one wavelength long.

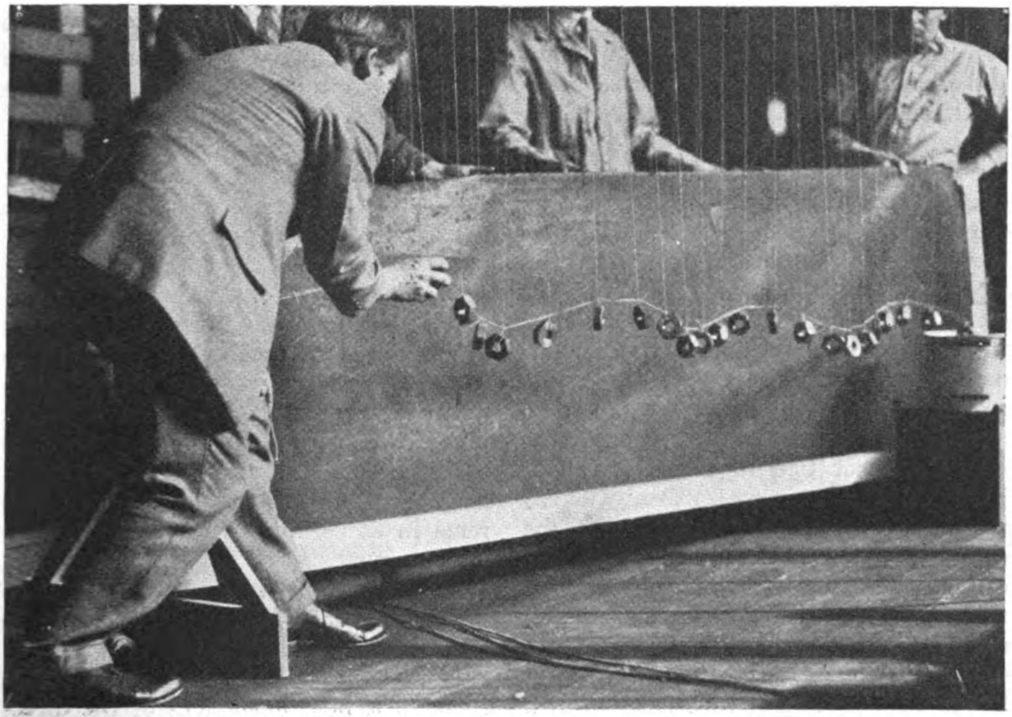
Another peculiarity of the observations of radio waves known among aviators is the fact that direction finder bearings on an airplane are correct only if the plane flies in the line towards the observing station. If the airplane flies at right angles, the direction finder gives false orientation as high as 45 degrees or more. It is also known that this false orientation is



From a photograph made for POPULAR RADIO

HOW A RADIO WAVE PRODUCES GROUND CURRENTS AT A DISTANCE FROM THE TRANSMITTER

The smaller set of weights (at which Mr. Alexanderson is pointing) represents earth currents that are set up by the radio waves which are represented by the large upper weights. When the apparatus is set in motion, a regular wave-form is set up in the lower set of weights by the action of the upper set of weights operating through the rubber bands.



From a photograph made for POPULAR RADIO

A DEMONSTRATION OF THE "CORKSCREW WAVE"

The author is here shown setting up a corkscrew wave motion by means of his mechanical "analogy machine." Notice how the rubber bands govern the motion of the whole wave; they have the same effect upon the separate weights as the elastic transmission medium would have upon the electrons in a radio wave itself.

greater if the antenna is trailing horizontally. It is, therefore, attempted to keep the antenna as vertical as possible by a weight.

A third set of observations has been brought out through the research work in Schenectady on horizontally-polarized waves radiated by a horizontal loop. Measurements with a direction-finder receiver usually give bearings approximately at right angles to the place where the station really is, but sometimes it gives no direction indication at all. Other measurements indicate that the direction of wave propagation is almost straight vertical. The observation that the wave appears to come straight down from above suggested an explanation that wave components radiated directly upwards had been reflected straight down by the Kennelly-Heaviside layer. This explanation seems however less likely in view of the other facts to be considered.

Putting all these facts together it seems now that the old observations on the long wave, the airplane and our recent work on the horizontal loop can all be explained as a characteristic behavior of the horizontally polarized wave.

In all three cases the wave *appears* to come in from the side, but actually it does not. When in the third case there is no direction indication whatever, and the wave appears to come in from above, this is also an illusion.

The question is: what does really happen?

This is the problem on which the experiment with the mechanical model can throw some light.

We must for this purpose return to the idea that the radio wave is a mechanical wave motion in the elastic electric medium. In the mechanical model the weights represent the mass and the rubber bands the elasticity of this medium and the vertical as well as horizontally-polarized wave can easily be reproduced. But when we are to imitate a wave motion over the surface of the earth, we must also in some way imitate the presence of the earth. The earth is a conductor and therefore the elastic strains represented by the rubber bands cannot exist in the earth. Displacement currents in the electric medium can, on the other hand, induce conduction currents in the earth. These conduction currents are moving electrons which may be represented by weights which are not tied together by rubber bands in the horizontal plane, whereas they are electrically associated with the electric medium above. To imitate this condition, weights were hung by vertical rubber bands so that they were elastically associated by the wave medium but not connected to each other. Now if a horizontally-polarized wave is sent forth through this system, it is found that the wave motion is propagated to the vertically suspended weights producing elastic strains in the vertical rubber bands.

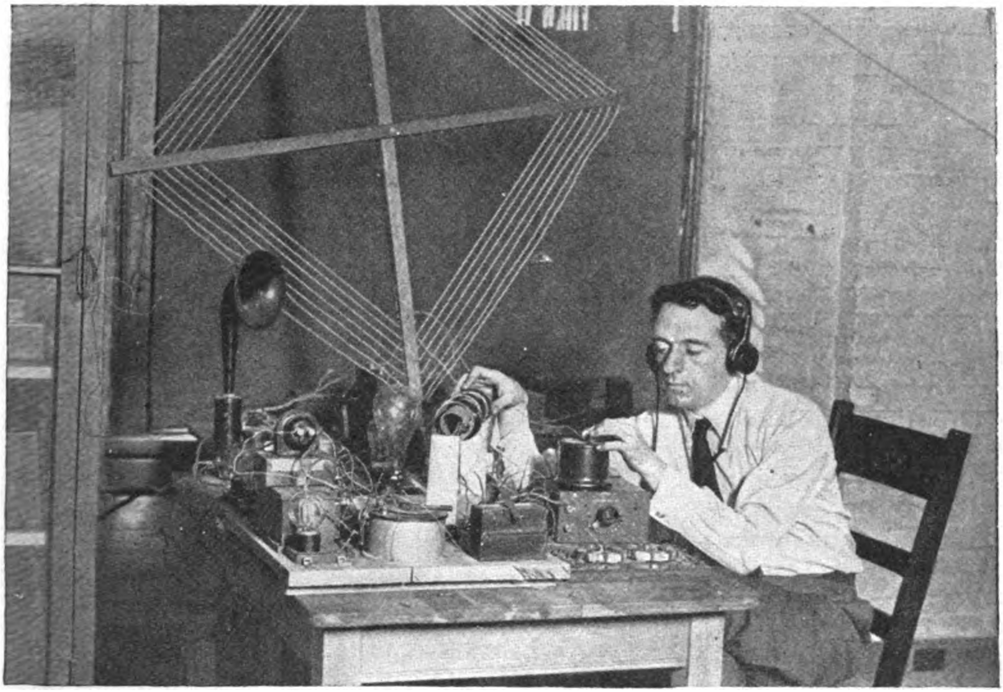
We must remember that the elastic strains represent electromotive forces and these elastic strains so produced are of the same character as if they were a part of a vertically propagated wave motion. Actually no such wave motion exists and these electromotive forces are only the electromotive forces which induce currents in the ground. If we now assume that we set up a receiving antenna in the form of a vertical loop with its plane at right angles to the wave motion, the primary wave motion does not induce any currents in the loop. However, the secondary electromotive forces which induce currents in the ground are in the plane of this loop and do tend to induce such currents in the loop.

We have thus been led by the mechanical theory of wave motion to attribute certain well-known phenomena to ground currents caused by horizontally polarized waves. It is, however, possible to come to the same result with the electromagnetic theory and give a better quantitative treatment of this problem with the help of mathematics.

Looking upon the problem in this way, we will assume that a horizontally polarized wave travels parallel to the earth. The electromotive forces and the displacement currents are horizontal and the magnetic lines of force are vertical. Thus the magnetic lines terminate in the ground. The magnetic lines are sweeping away from the radiator like alternate north and south poles of magnets pointed into the earth. According to the laws of magnetic induction these sweeping magnetic poles will produce eddy currents in the ground which in their turn induce currents in a direction-finding loop. An apparent orientation is therefore found at right angles to the direction of wave propagation.

If this theory is correct, it should be found that false indications of the direction finder and the apparently vertical wave propagation can be observed only in the proximity of "ground." Thus if observations are made in airplanes high enough over the ground, the horizontally polarized wave should show a horizontal plane of polarization with a true direction of propagation.

It is hoped that with the co-operation of the government such observations may be made. If such tests give the results predicted it may be concluded with reasonable assurance that the peculiar phenomena of false indication of direction finders which have been known for some time may be explained as a normal characteristic, indicating the presence of horizontally-polarized waves. This theory also explains why the existence of horizontally-polarized waves has so long been neglected because it has been shown that a horizontally-polarized wave can be received on a vertical loop but not on a horizontal loop. It will also give us greater confidence in the use of the mechanical theory of wave motion for explaining other phenomena of wave propagation.



Kadel & Herbert

THE UNIVERSITIES TRAIN ENGINEERS FOR THE RADIO INDUSTRY

The demand for experts is being met in part by technical schools and universities where courses in electrical engineering are preparing technical men for positions with business corporations. Such engineers usually earn from $2,500 to $7,500 a year in salary; some consulting engineers have earned as high as $100,000 a year.

Radio as a Life Work

Where the opportunities lie for the experimenter who wants to earn his living in this new field of science and industry

By PIERRE BOUCHERON

THERE are at present some excellent opportunities in both the commercial and engineering fields of radio —with perhaps a slight preference for the first.

The engineer who spends a lifetime in research, designing and experimental work is likely to follow a very ethical pathway. In many instances the lure of money or profit in his profession is somewhat distasteful, and, providing his income is sufficient to take care of his immediate needs, he is usually satisfied with his lot.

The commercial man, on the other hand, is apt to view things in a different light. His training and qualifications are concerned with chasing the almighty dollar. It is his job to make sales for his company; for that reason, the viewpoint of the commercial man is closely associated with money-making and he is apt to apply the same principle to the matter of salaries and commissions. The commercial side of any industry is consequently often more profitable than the engineering end.

This article is not concerned with the commercial radio man.

Whether or not a man chooses the engineering side of radio as a profession is, after all, a matter of individual temperament and disposition.

As a matter of fact, there are many engineers who have branched into the commercial end of radio, and there are likewise men starting in commercial capacities, who later find engineering more suited to their individual ambitions.

Radio engineering does not require very many men, but the few who are required must be good. There is, however, a growing need for operating men, particularly at high-powered land stations. By "operating men," is meant not so much telegraph operators as men who are well versed in the fundamentals of radio and who have a fair technical training as well as a practical one—transmitting and receiving engineers for example, and men who are trained in the installation, operation and care of high power transmitting and receiving apparatus, and who are telegraphers as well.

Radio as it is today has branched out considerably into many sub-divisions. An important development of recent years has been transoceanic radio telegraphy. This country has made active progress in transoceanic communication and a number of radio stations have been erected on both the Atlantic and Pacific coasts which are designed for high-powered long-distance transmission and reception. In this field, therefore, there is need, and probably always will be, of men capable of handling the operating details of these high power equipments.

What are the duties of transmitting and receiving engineers at high power stations?

The transmitting engineer at a high power station may aptly be called a shift engineer. His duties correspond somewhat to those of an engineer at a central power plant and the experience he gains here may come to him in good stead should he later engage in regular power-station work.

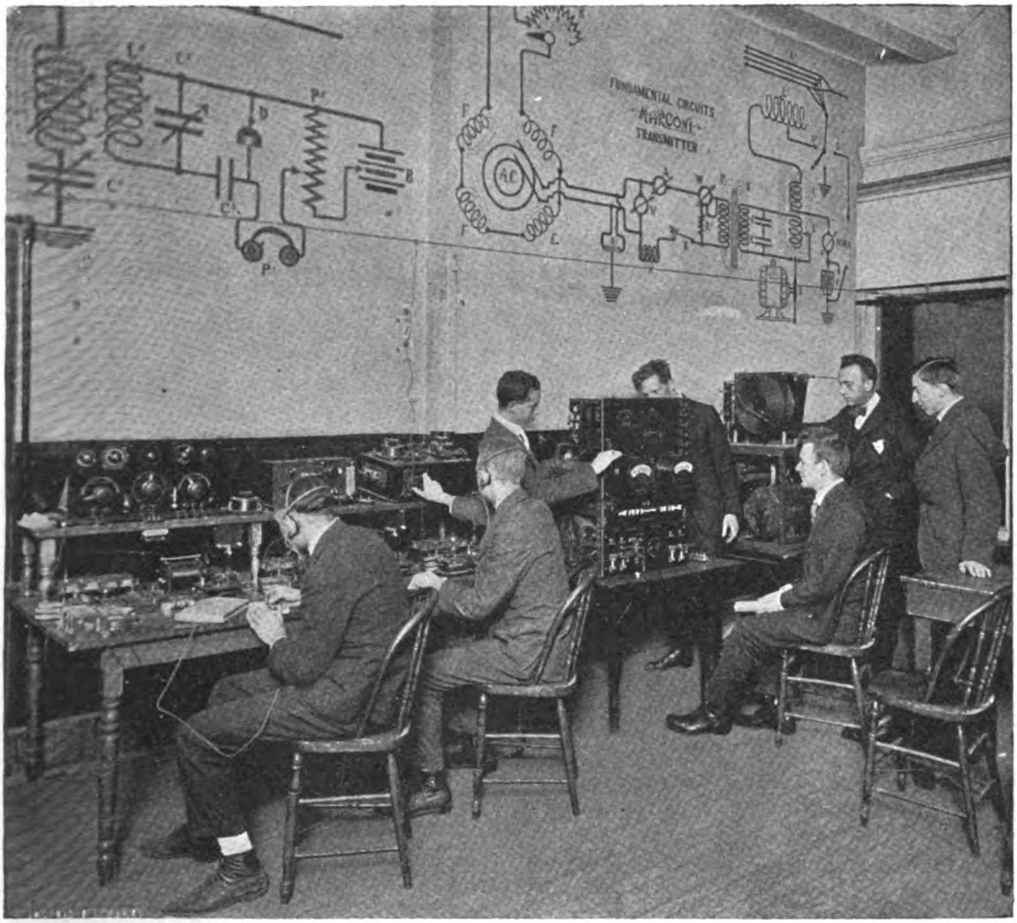
In addition to this, he has the advantage of being in close touch with the latest applications resulting from modern scientific discoveries in engineering practice. Of late, radio has struck a new cord; and its principles are rapidly finding uses in all manner of allied engineering such as telephony and telegraphy.

It is the duty of a shift engineer to keep the apparatus moving. He must see to it that the power supply is constant, that the cooling system connected with the efficient operation of the high frequency alternators is in working order, that the remote control system is operating at such speed that 50 or more words a minute may be possible at any moment. Incidentally, the speed control of high-frequency alternators must be very accurate and the methods which have been devised to accomplish this are novel and instructive from an engineering point of view.

The problems of the receiving engineer are somewhat similar but on a smaller scale. The battery supply must be kept quiet and constant and the receiving equipment must ever be in a highly effective working order. These factors are of great importance in reception.

The receiving engineer is perhaps more in touch with the immediate development of radio than anyone else, as it is necessary for him to secure the facilities for handling as great an amount of traffic as possible with the apparatus available. The work, therefore, calls for considerable ingenuity.

The man who has a good electrical engineering training and who has devoted a certain amount of time to amateur radio experimentation naturally has the



Radio Corporation of America

HOW RADIO OPERATORS ARE INSTRUCTED

Amateurs as well as "fans" without technical knowledge are turned into radio operators in radio courses that are conducted by private institutions and by some few business corporations. A ship's operator earns from $1,000 a year to $1,800 with board.

advantage in such work. There are many electrical students who are amateurs, with such training and as electrical engineering has been foremost in their minds, radio has occurred to them as a possible career.

There is a good future for competent radio engineers; men who have considerable experience and who understand the problems involved in making radio fool-proof. In fact, there are today many serious difficulties to be overcome. Here are some of them:

As many tropics-bound ship operators know, we have in radio a strong negative factor in the masterful and ever present "static" which also bears the less popular name of "strays." These atmospheric electrical disturbances cause objectionable noises in the receiving telephones of the operator. For this reason, parts of messages are often mutilated. In fact, when static is very severe (as during heavy electrical storms), radio reception often has to be abandoned for lengthy and costly periods. This problem is probably the most important one that requires solution today. It was discovered a short time ago that static waves seem to travel largely from a particular direction which is frequently different to the incoming radio signals. The final elimination of static is a problem that is not going to be solved overnight; it will rather be a gradual process. It will probably be a long chain of personal achievements of many engineers when finally static will be entirely controlled or eliminated.

A scheme to overcome static has been employed which may aptly be termed the "dodging" method. In this case there are possibly three separate trans-oceanic receiving stations located at various points along the coast each separated by a distance of 400 or 500 miles. The plan is for each of these stations to receive the incoming signals and simultaneously transmit them over a land line to a central receiving point, such as New York. The method of reception at the central point may be any recording method which will permanently register the signals on paper tape. The central receiving operator thus has three tapes passing his line of vision which record the same message. As in most cases static is of local origin, it is assumed that only one of the stations will be affected at one time and that the other two will receive the signals without mutilation. Thus, if one of the tapes shows static interference, there remain two others for checking purposes.

Another problem which requires solution is that of making radio communication secret so that transmitted signals cannot be intercepted by either competing organizations or by foreign governments, who may, by following the simple expedient of setting up receiving installations, "listen-in" and copy what is going on in the ether.

Another problem in radio is that of perfecting a reliable calling system for use primarily on board vessels. At present it is necessary for an operator to be constantly "listening-in" in order to know whether anyone is calling him.* Some interesting developments in this direction have been made by our English colleagues, but they have plenty of room for perfection.

High speed radio telegraphy has been receiving attention and several systems are known to work satisfactorily. But these are practically useless when static is very severe. For that reason, there is need of a certain amount of development in high speed transmission and reception, so that the transmission and reception of international messages can be made a profitable one for those engaged in it.

A recent development has been the so-called "wired-wireless" experiments in which radio is made use of in long distance wire telephony and telegraphy. Effective multiplexing is made possible by the use of radio waves which are guided by wires. In fact from six to ten simultaneous channels of communication are sometimes available on a single wire line. These experiments indicate that we may reasonably look forward to transoceanic cable telephony.

Radio direction finding is proving invaluable in maritime circles, but it has not reached perfection by any means. Here too there is need of radio engineers who will specialize in direction-finding work exclusively.

An appliance which has well nigh revolutionized the radio world, with special emphasis on radio telephone broadcasting, is the vacuum tube. The vacuum tube today is truly the "heart of radio." It has the unique characteristic of performing all the essential functions of generating and modulating the high-frequency power of the transmitting station, and it may also be used to receive, rectify, and amplify the received power at the receiving station. Not only does it prove excellent in radio telegraphy but is exceptionally well adapted for radio telephony.

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* See POPULAR RADIO for June, 1924.

Radio Corporation of America

WHERE THE "COMMERCIAL TRAFFIC WORK" OF RADIO IS CARRIED ON

With the constant increase in the number of radiograms and the building of new radio-telegraph stations throughout the world, the demand for help is growing proportionately. Men who handle the routine message work in such a trans-atlantic radio-telegraph operating room as shown above, usually get from $1,500 to $2,700 a year.

We have, therefore, in the vacuum tube another angle of radio which will require specialized attention by competent electrical engineers of the future. The vacuum tube is not only used in radio but it has found its way to advantage in ordinary wire telephony and other electrical uses which makes us realize that electrical engineering is closely associated with radio engineering.

In fact, one cannot be a good radio engineer without being well founded in electrical principles.

As an illustration of how closely radio is associated with wire telephony and telegraphy, it may be recalled that the American Telephone and Telegraph Company gave a demonstration before the International Communication Conference, who were able to listen to conversation going on between a ship in the Atlantic and a small island in the Pacific. In this instance, radio was linked with the regular land telephone lines and necessitated the combined co-operation of radio, electrical and communication engineers.

Another illustration was the duplex radio telephone feat between the *S. S. America* and the Deal Beach radio telephone station, accomplished by the combined engineering skill of the Radio Corporation of America, the American Telephone and Telegraph Company, the Western Electric Company and the General Electric Company.

Ewing Galloway

THE RADIO FAN WHO IS "HANDY WITH TOOLS" USUALLY STARTS IN A FACTORY JOB

If he has inventive talent, his career will lead upward indefinitely. Mechanics usually start in at such work at about $1,100 a year; a skilled mechanic may get from $1,800 to $3,100 a year, and inventors sometimes get in addition a share in the proceeds of their inventions.

But perhaps the most important and far-reaching opportunity in radio is radio broadcasting.

The ether in and near large cities that are served by broadcasting stations is literally packed with music, lectures, news, children stories, market and weather reports and what not. Radio telephone development is responsible for this tremendous interest. Recent estimates of the number of radio broadcast enthusiasts place this figure at approximately three million!

Men and boys who a few months ago did not know a vacuum tube from an electric lamp are today holding neighbors spellbound with their glib radio vernacular. Parents are beginning to look upon their radio amateur sons in a new light—as future Edisons and DeForests and Marconis. A great many youths are naturally gravitating toward radio as a profession; they need help and timely advice.

Meanwhile, however, man, woman and child want to hear "the voices from the air." They need apparatus for this—apparatus that is effective. Already the radio public is beginning to discriminate. There is, therefore, an excellent chance for the conscientious engineer who wishes to see broadcasting and amateur radio a part of every day activity. As radio progresses, there will be need of more exact methods in the designing and manufacture of apparatus. Moreover, these factors will necessitate careful consideration by future radio engineers.

The broadcasting and amateur side of radio is one which today plays a very important part in general radio development. In fact, amateur radio has contributed in a great degree to the general progress of the science.

A leading radio engineer recently emphasized the need of good radio men. He thought that radio as a commercial and professional possibility had been given altogether too much publicity and that its future had been painted in too glowing colors. For that reason he thought there were too many men attracted to it who were not especially equipped either by inclination or education to take up radio as a profession, and would ultimately retard rather than advance the art.

This engineer carefully gleans every patent which is directly or indirectly connected with radio that is issued by the United States Patent Office. His conclusions are that there is probably only one out of every 1,000 patents issued which is really of any value to the development of radio. The 999 remaining patents are so called "paper patents" and are practically worthless. Incidentally, they reflect the lack of knowledge and experience which these would-be inventors hold. Many of these documents have been prepared by men who have a vague and hazy idea of radio fundamentals. In short, there is too much negative activity connected with radio and there is need of some real constructive and really worth while work along these lines.

It would seem, therefore, that if any competent electrical engineer is contemplating specializing in radio the field is open to him for recognition providing that he is willing to keep his feet on the ground and "lay off" on radio dreams and impossibilities. There is, of course, nothing to stop an electrical man from pursuing a strictly electrical career and at the same time resort to radio as a hobby whereupon he may by due process of experimentation and research strike something of real importance and benefit to the art.

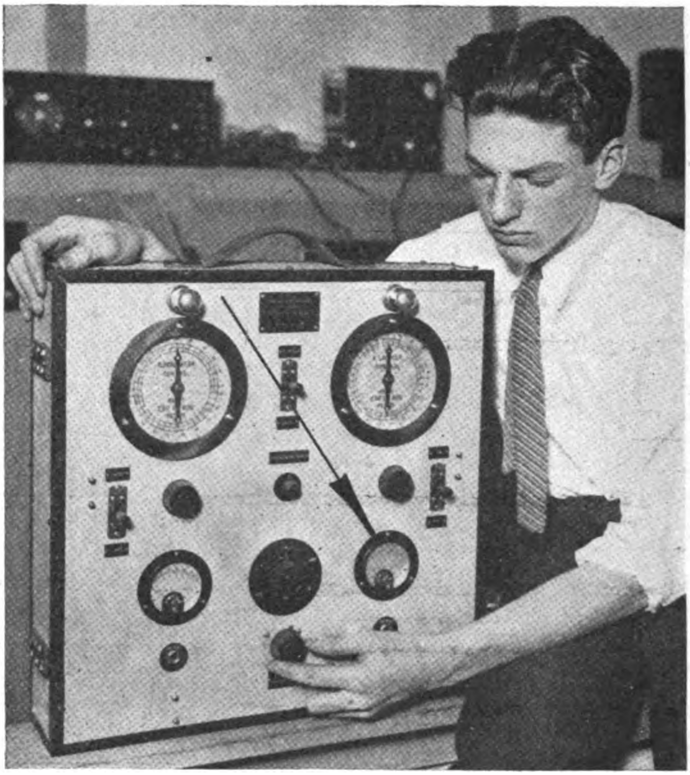
There is a growing number of universities and colleges in this country that have recognized the value of radio by making it part of their regular engineering courses. Some of these are Columbia University, Cornell, Rensselaer Polytechnic Institute, Yale, Harvard, Massachusetts Institute of Technology, Pennsylvania State College, Polytechnic Institute of Brooklyn and several other education institutions.

The most practical way to learn radio properly is to become first an electrical engineer or at least to become well-grounded in electrical principles through amateur experimentation or intensive training at a good radio institute. In this way the student may acquire enough radio knowledge to enter the service of one of the several large radio companies in one of their branches, such as designing, construction work, manufacturing, operation or maintenance.

The men who are today well known in radio circles and who have fared well are those who have followed these or similar lines.

A New Power Amplifier Unit

In the April issue of Popular Radio *will appear the first complete description of a new unit that will be the forerunner of many audio-frequency amplifying devices of the future. The article will describe a power amplifier unit that will provide straight audio-frequency amplification with a minimum of distortion. The unit comprises one stage of transformer-coupled audio-frequency amplification and it will supply the A, B, and C voltages to the power amplifier tube in the last stage; it will also supply B and C voltages for the first stage of amplification and will supply the B current for any set with which it is to be used. When added to any set that employs one, two or three tubes, it will give reproduction of that lifelike tone quality and volume that will enable the filling of a large hall or auditorium with concerts.*



Kadel & Herbert

A RECEIVER THAT IS WELL EQUIPPED WITH METERS

By mounting the milliammeter directly on the panel of the radio receiver the operator has an indication at all times that the vacuum tubes are functioning properly. The instrument is indicated by an arrow.

WHY AND HOW THE MILLIAMMETER INCREASES

The Efficiency of Your Set

To keep you advised of the drain on your "B" batteries, to show you whether there is distortion in your audio-frequency amplifier and to act as a warning signal in case any other circuits in the receiver go wrong—these are the functions of this instrument.

By MAURICE M. OSBORNE

A DIRECT-CURRENT milliammeter is an electrical measuring instrument which looks and is built like a voltmeter but which measures rate of current flow or consumption instead of its voltage or pressure. It makes this measurement in milliamperes (thousandths of an ampere) and is used in radio for indicating the rate of current flowing from the "B" battery through the plates of the vacuum tubes.

Few set owners or builders have not at some time or other been appalled by the unexpectedly rapid running-down of their "B" batteries through excessive drain. This is particularly so in the case of sets that employ high "B" voltage on the audio-frequency amplifiers and without grid-biasing means ("C" batteries).

The "B" battery current can flow only when the filament of a tube is lighted. Turning the "A" current on the tube-filament heats it. As soon as it has sufficient voltage impressed upon it and the temperature has risen to a critical point, the heated filament begins to emit electrons or tiny negative charges of electricity. These electrons start to flow to the tube plate, which is charged positively from the "B" battery, and therefore attracts them. The grid of the tube may be disconnected and there will still be this flow of "B" current, as long as filament and plate are properly wired to the "A" and "B" batteries.

Now the grid acts like a shutter on the flow of electrons, being wide open and permitting a large flow when it is charged positively and more and more closed to the electron flow as it becomes charged more and more negatively. The "B" current flow may be increased by connecting the positive side of a grid battery to the grid and it may be decreased by the opposite means.

This is why the use of grid biasing or "C" battery economizes "B" battery current.

The most generally useful position of the milliammeter in the radio set is on the minus "B" lead, between the set and the battery. To connect, attach the binding post of the meter marked (+) to the "B" negative post on the set, with a short insulated wire. Attach the "B" negative lead from the battery to the other post on the meter. The meter will now show the total amount of "B" battery current that is being used at any time. To safeguard the meter from excessive current from accidental short circuits caused by dropping a screwdriver into the set, or making an incorrect connection, a 10 watt, 110 volt lamp may be connected in series with the meter.

The meter should show no reading when the "A" battery is turned off. If it does, there is a short-circuit somewhere. This is the first useful purpose of the milliammeter—it detects even very minute short-circuits in the radio set. If such a reading appears, with the "A" battery switched off, the position of the short-circuit should be tested for with a voltmeter, keeping one side of the meter attached to the "B" negative lead and exploring with the other lead from the meter.

It is far safer to remove all of the tubes when this is being done, to remove the danger of burning out tubes.

The milliammeter will immediately show a reading, which for a five-tube set may be as high as 20 to 40 milliamperes, if there are no "C" batteries used and the "B" voltage is high on the audio-frequency tube plates. But such a high "B" battery current is entirely unnecessary and may be at least halved by the proper use of "C" or grid-biasing batteries, with an improvement in faithfulness of reproduction at the same time.

If the set does not use "C" batteries, they may be installed as follows:

All the battery-cable leads should be disconnected at the batteries, to avoid danger of short-circuits, when working around the set. Then the wiring should be disconnected from the binding post marked "filament" or "—" of each of the audio-frequency transformers.

Assuming that there are two audio-frequency amplifying tubes, each with a transformer and each with about 90 volts of "B" battery on the plate, the set should have one or two 4½-volt "C" batteries. The negative side of one each of these "C" batteries should be connected with a short wire to the transformer binding post marked "filament" and the wire which was taken off the transformer should be connected to the positive binding post of the "C" battery, thus connecting the "C" positive to the "A" negative. Flexible leads with Fahnestock clips should be used and the "C" batteries should be placed in the back of the cabinet, behind the tubes.

Then the batteries may be connected and the set tuned.

The experimenter will note an immediate reduction in the reading in the milliammeter and an improvement in quality of reproduction.

For still greater improvement, four 45-volt batteries may be used instead of two 45-volt "B" batteries. A voltage of 90, or two "B" batteries may be put on the plate of the first audio tube (first after the detector), and a voltage of 180, or four full "B" batteries, on the plate of the last tube. A grid battery of 4½ volts may be used on the first tube grid and a small 22½ volt "B" battery with taps at 16½, 18½, 21 volts for the second tube grid-battery. The experimenter. may try different grid biases on this last tube; probably about 18 volts will be good, but the best bias is determined by ear.

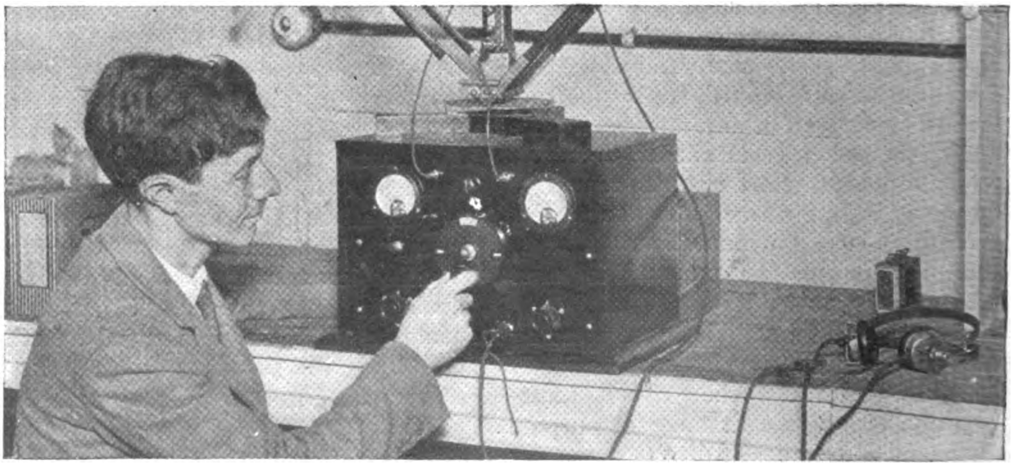
Still further improvement will result from the use of another tube in parallel with the last tube. This may be done by installing a new socket beside the last tube—and connecting grid to grid, plate to plate, "A" positive to "A" positive and "A" negative to "A" negative with short leads of insulated wire.

Although the ear is the final judge of perfection of reception, it is a condition of distortionless amplification that the needle of a milliammeter in the "B" negative line will show no movement whatever while the set is operating. With insufficient voltage on the plates of the tubes in a transformer-coupled audio-frequency amplifier, the milliammeter reading will increase with a loud signal. If there is not enough "C" battery voltage, the reading will decrease on loud notes. Increasing the grid biases will correct this condition. If the milliammeter needle varies its position continually and over a wide range when signals are being received, there is sure to be distortion. The grid biases and "B" battery voltages should be adjusted so that the milliammeter needle remains absolutely still at all times that signals are being received.

The milliammeter will show with the above recommended high plate voltages, not one bit more current used than with the lower and less satisfactory voltages. The grid-batteries have reduced the current used.

If a "C" battery or grid connection breaks, abnormal current flow shows up the defect. If tubes go dead, a drop in the reading immediately points to the trouble. A leaky tube with a poor vacuum will be indicated by its abnormal draw of "B" current.

The experimenter should make a friend and adviser of his milliammeter. He will never regret it and will find it to pay in added enjoyment of programs.

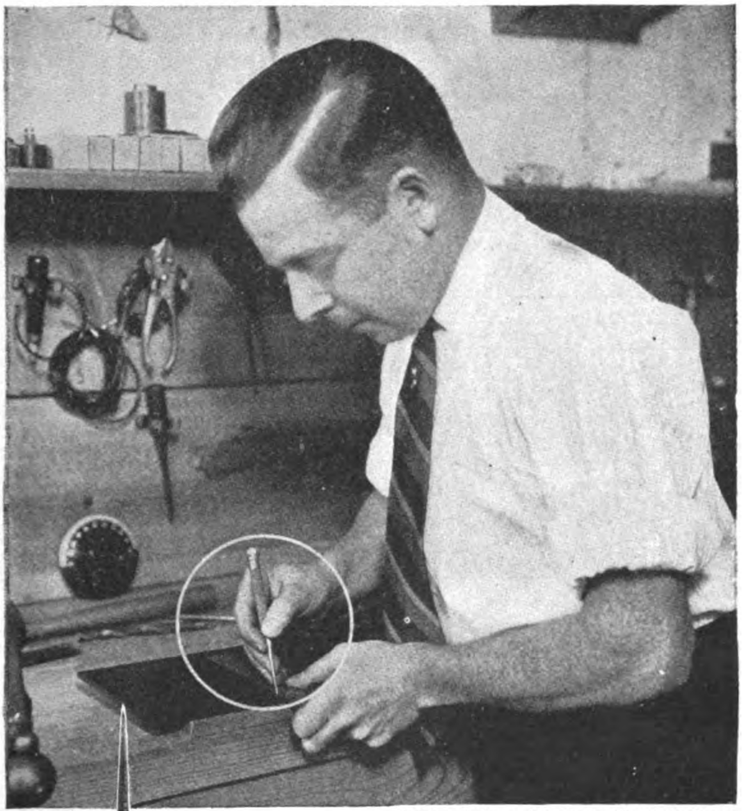


From a photograph made for POPULAR RADIO

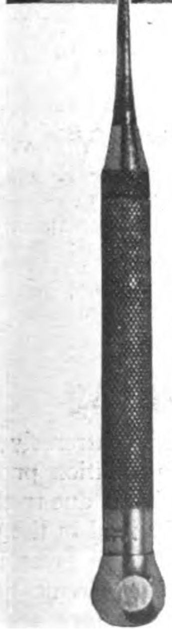
THE SINGLE-CONTROL SUPERHETERODYNE IS EQUIPPED WITH BOTH A VOLTMETER AND A MILLIAMMETER

A plate milliammeter is so necessary in adjusting the receiver to obtain the best results that it is included as an essential part of it.

Handy Tools for Radio Fans: No. 10



From a photograph made for POPULAR RADIO



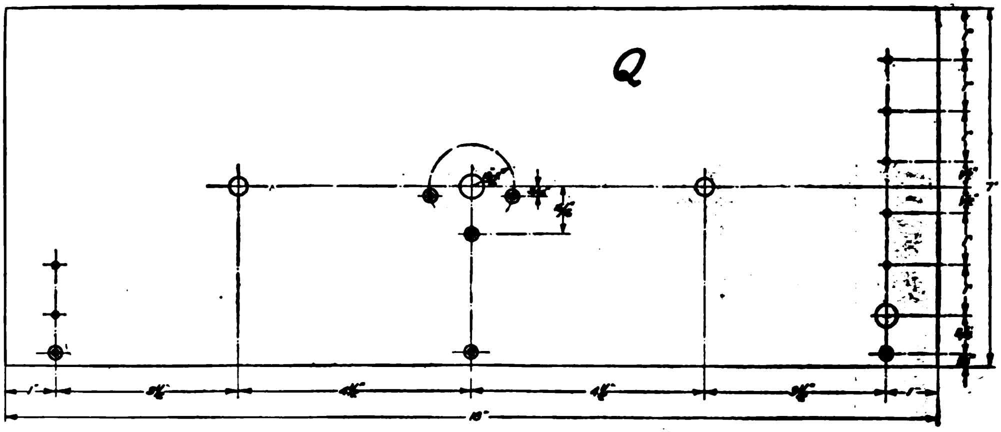
THE SCRIBER

A device for laying out the centers in drilling panel holes

AN instrument of this kind with a strong sharp point is always useful in the experimenter's workshop or laboratory for drawing lines on the back of panels or for laying out the centers of the instruments. It must not be confused with the center punch as it should never be struck with a hammer to make a deep hole. It is only used to make a slight pin prick at the place where the center punch will later enlarge the hole to start to drill.

The instrument is usually finished as shown in the photograph, with a knurled surface and a small knob at one end for applying greater pressure.

The preceding suggestions in this series were SIDE-CUTTING PLIERS, SCREW-DRIVERS, THE HYDROMETER, THE BATTERY-TESTING VOLTMETER, THE FILE, THE JACK KNIFE, THE ELECTRIC SOLDERING IRON, THE SOCKET WRENCH *and* THE HAND DRILL.



THE DRILLING PLAN FOR THE PANEL

Figure 1: *This drawing shows exactly where holes should be drilled in the panel for mounting the instruments. The holes which are outlined with a double circle should be countersunk. Always start drilling the holes in the panel with a small drill—one-sixteenth is a good size.*

Simple "How to Build" Articles for Beginners

No. 15

How to Build a Three-tube Four-circuit Tuner

By LAURENCE M. COCKADAY

Cost of Parts: *Not more than $42.50*
Approximate Range: *1,000 miles*

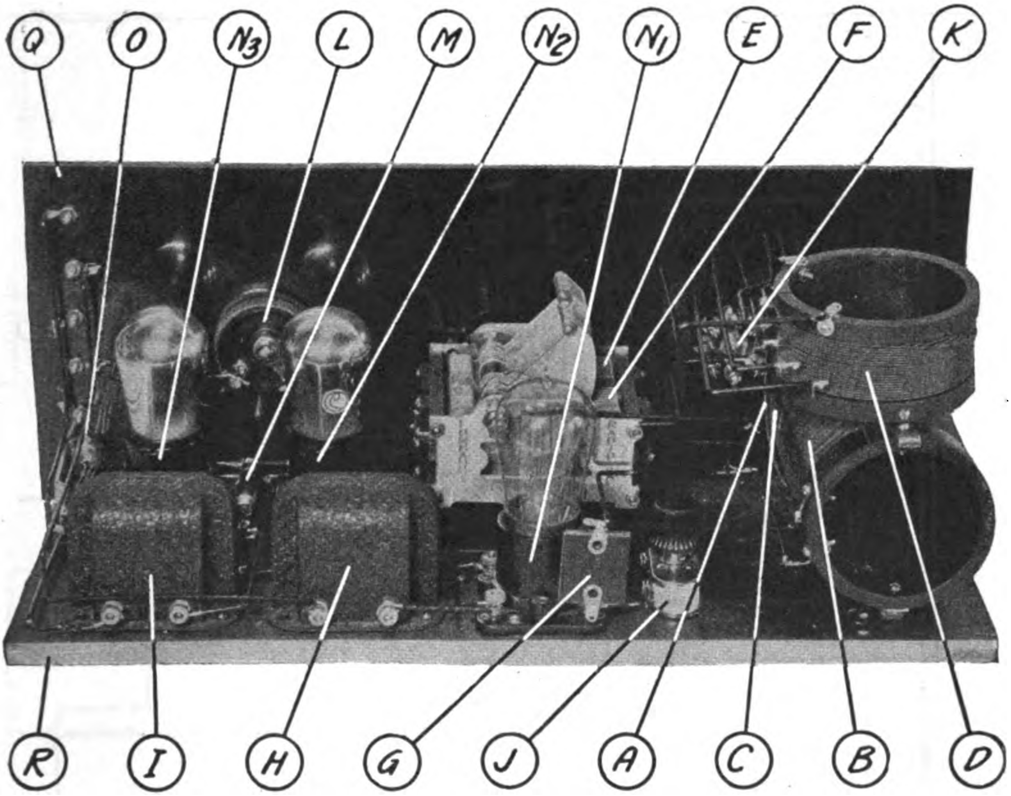
Here Are the Items With Which the Laboratory Model Was Built—

A, B, C and D—primary, secondary stabilizer and antenna load coils of the Precision Octaform four-circuit coil set;
E and F—two sections of the Lombardi dual SLF variable condenser, .00035 mfd.;
G—Aerovox mica fixed condenser, .00025 mfd.;
H and I—Perry audio-frequency transformers;
J—Bradleyleak;
K—Jones seven-point inductance switch;
L—E-Z-stat, 6 ohms;
M—Amperite No. 112;
N1—Benjamin Cle-Ra-Tone standard socket;
N2 and N3—Na-ald De Luxe socket No. 400;
O—Yaxley open-circuit filament lighting jack;
P—Gee-Haw vernier dial;
Q—panel, 7 by 18 inches;
R—Baseboard 6¾ by 16¾ inches;
Seven Eby binding posts.

THIS model receiver, which has been added to this series of simple sets for the beginner, utilizes the principle of the four-circuit tuner as it was first produced. That is, it consists of a detector and two stages of transformer-coupled amplification.

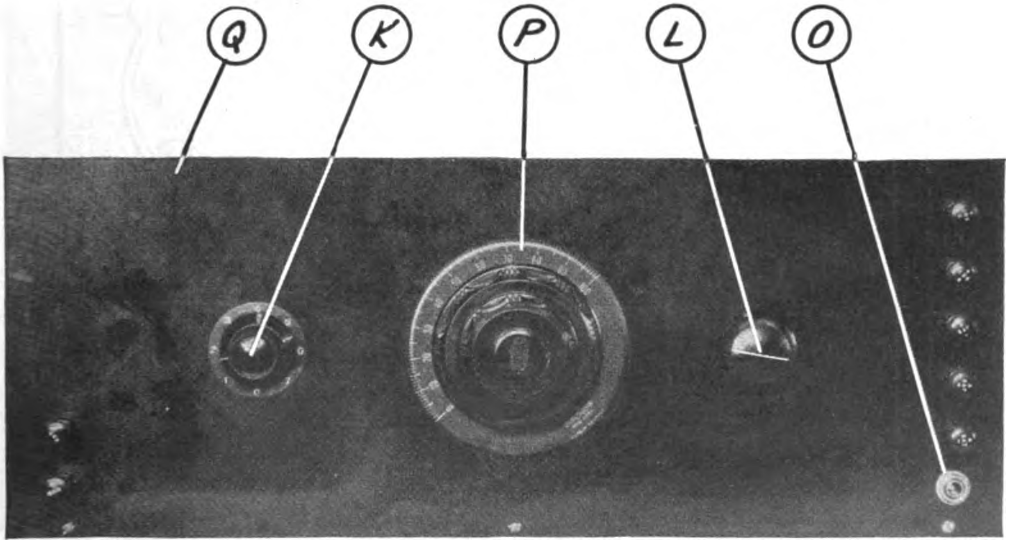
The set is not as costly as the five-tube receivers but it is extremely efficient and selective and in addition produces a fine tone quality which is due to the quality of reproduction obtained in the amplifier.

It incorporates one great improvement over the old four-circuit tuner in that both of the condensers are coupled together on one shaft in accordance with



A VIEW OF THE SET FROM THE REAR

FIGURE 2: *This picture diagram shows the general arrangement of all the instruments.*



THE PANEL ARRANGEMENT

FIGURE 3: *A front view of the panel is shown here. The lettering used here, as in the other illustrations, corresponds exactly with that in the list of parts.*

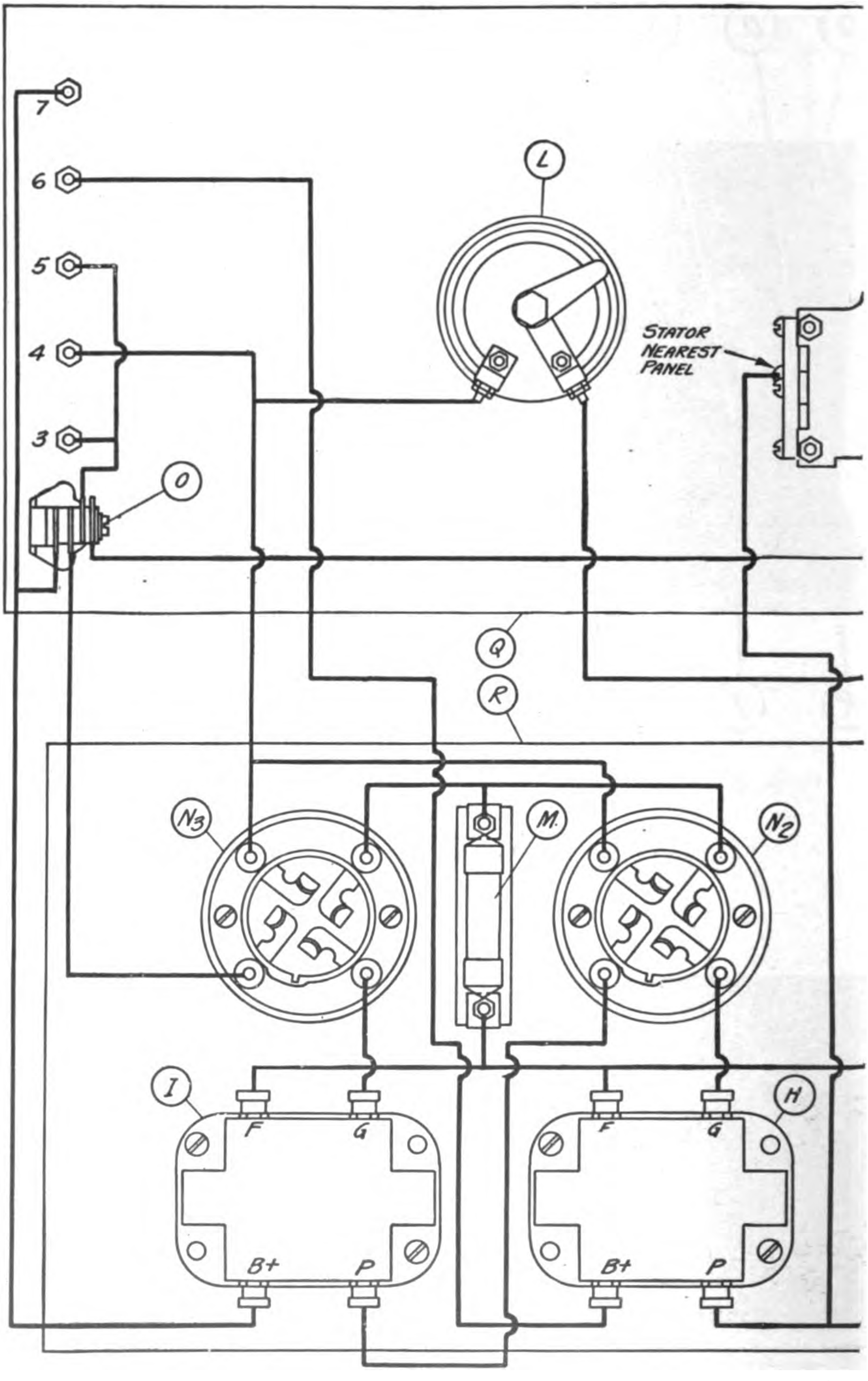
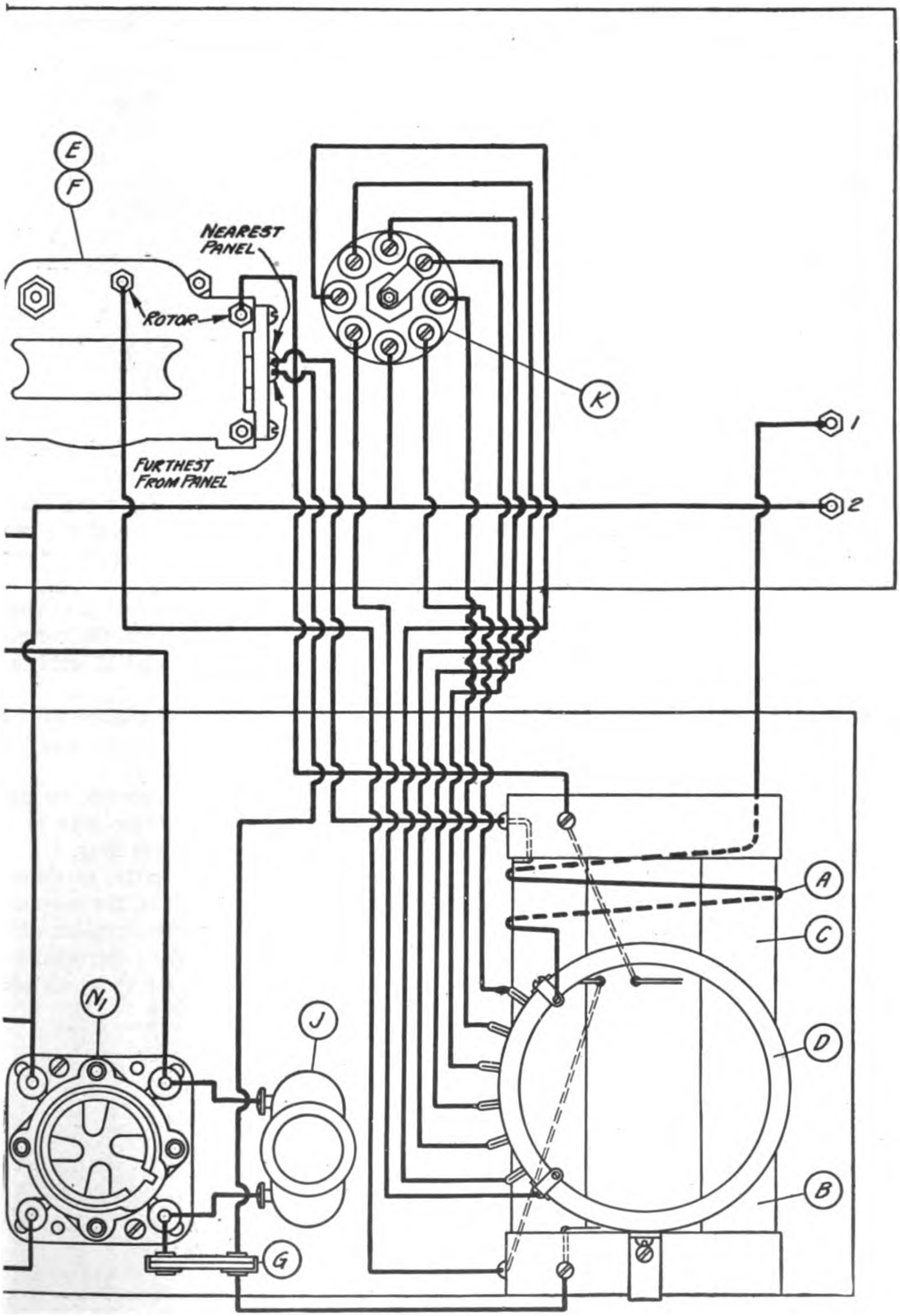


FIGURE 4: *A picture diagram that gives the connections between the various rectangle represents the baseboard, while the instruments are drawn as nearly as*



instruments of the receiver. The upper rectangle represents the ***panel and*** *the lower possible in the positions in which they will appear.*

the modern trend towards simplification of tuning. Another improvement is the employment of a simple inductance switch that does away with many holes in the panel and with the hard work of drilling them.

This receiver will be found easy to operate, and with it the beginner should be able to bring in distant stations on a loudspeaker.

The set operates from a six-volt storage battery and two 45-volt "B" batteries and is, of course, regenerative. However the coupling between the oscillating circuit and the antenna circuit is so loose that radiation is practically eliminated.

The unit that is described here was built and carefully tested in the Popular Radio Laboratory.

Take this issue of the magazine to a radio store and ask the dealer to supply you with the parts necessary to build the receiver, which are listed at the head of this article.

Then take the parts home and drill the panel Q as shown in Figure 1 which gives the size of the panel and the correct spacing for all the holes that are used to mount the instruments and binding posts.

Next mount the instruments in their correct positions on the panel and baseboard as shown in Figure 2. When this is done, wire up the instrument with standard round bus wire as indicated in Figure 4.

When you have finished wiring up, connect the antenna, ground and batteries to the binding posts in the following manner:

Connect the antenna lead wire to binding post 1 with the ground wire running to binding post 2. Connect the two 45-volt "B" batteries in series and connect the positive 90-volt terminal to binding post 3. Connect the positive 22½-volt tap to binding post No. 4. Connect the negative terminal of the "B" battery to binding post No. 5.

Then connect the 6-volt "A" battery across binding posts 6 and 7 with the positive terminal connected to post No. 6 and the negative terminal connected to post No. 7.

Insert in socket N1 a UX-200 detector tube and place two UX-201-a tubes in the two remaining sockets. Place the loudspeaker plug in the jack O and the two amplifier tubes should immediately light up to the correct brilliancy.

Finally adjust the rheostat L so that the detector tube burns with the correct brilliancy and rotate the dial P until the stations are picked up.

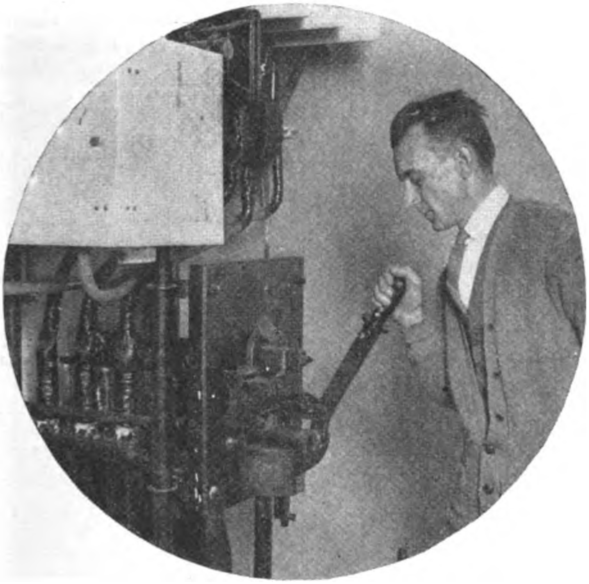
The best selectivity and volume will be obtained by rotating the inductance switch knob K to the right number.

The correct type of antenna to use with this receiver is a single wire or a double wire 100 to 150 feet long.

If the set is built correctly, as shown in the diagrams and pictures, the operator will find, after he becomes familiar with tuning, that he will get good reception on the loudspeaker from stations which are up to about 1000 miles away.

A Storage Battery Charger That You Can Make at Home

In the April issue of Popular Radio *will appear another article of the simple "how-to-build" series. It will describe a storage battery charger that may be made at home by even an inexperienced radio fan at a cost of only a few dollars. This unit will operate directly from the AC lighting lines and will provide the experimenter with a reliable means for keeping his storage battery fully charged and ready for operation at all times.*



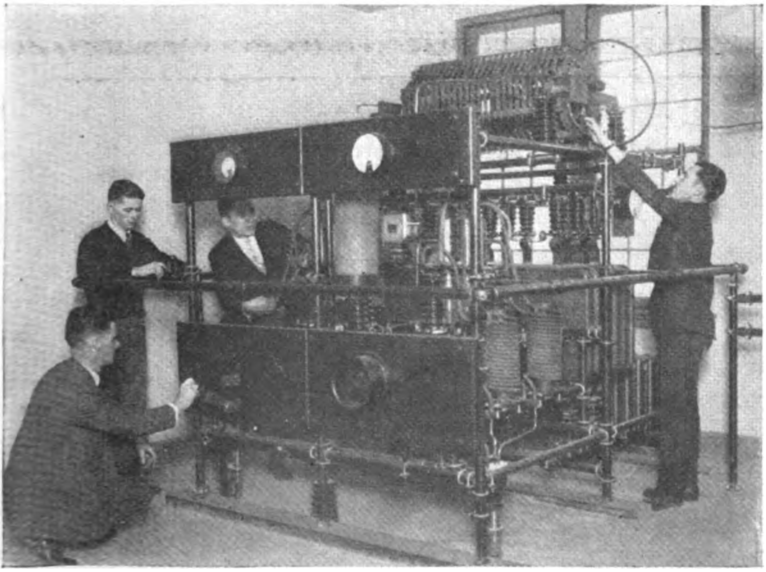
The master switch that controls the current of 4300 volts potential which enters the station from the power plant. It is the only switch in the station which is set by hand.

The upright short-wave antenna; half-way up is the antenna coil.

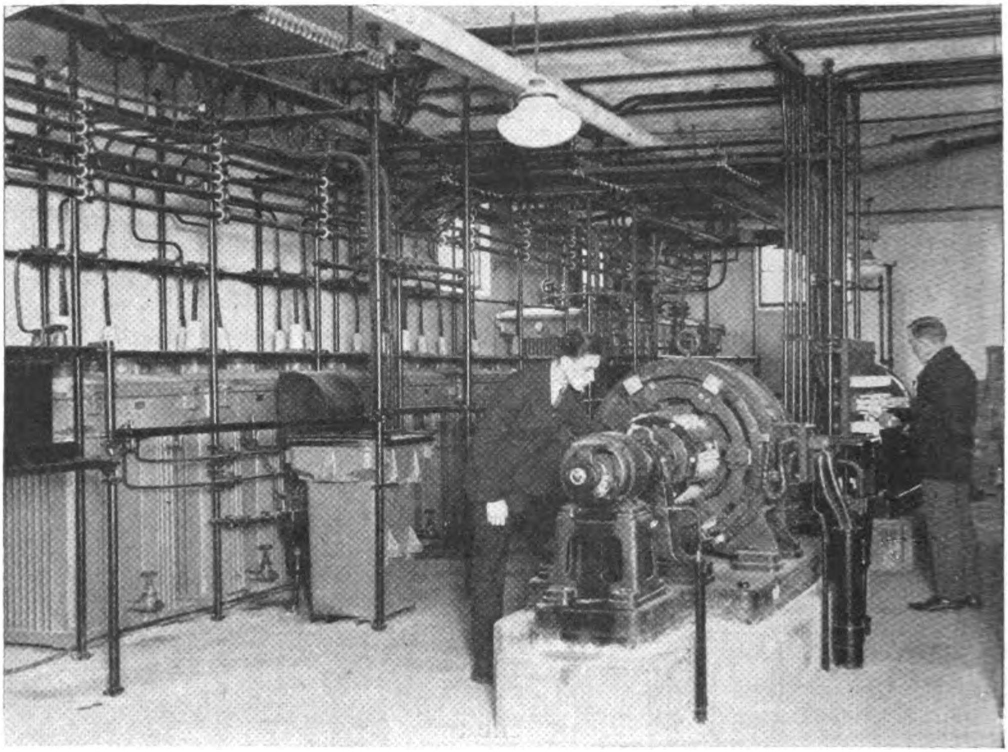
The New Lord *of* the Ether

Some of the unique features of the most powerful broadcasting station in America—2XAR, located at Bound Brook, New Jersey.

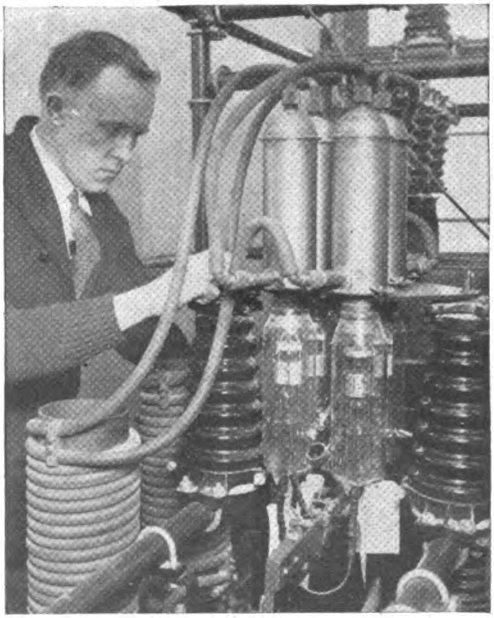
From photographs made by Kadel & Herbert.



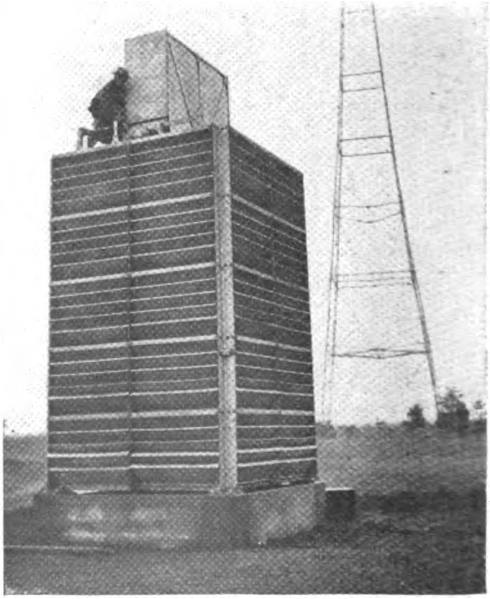
One of the oscillators of the 50-kilowatt transmitter which make the new Bound Brook station one of the most powerful broadcasters. The coiled tubing which supplies water to the huge water-cooled tubes is here shown.



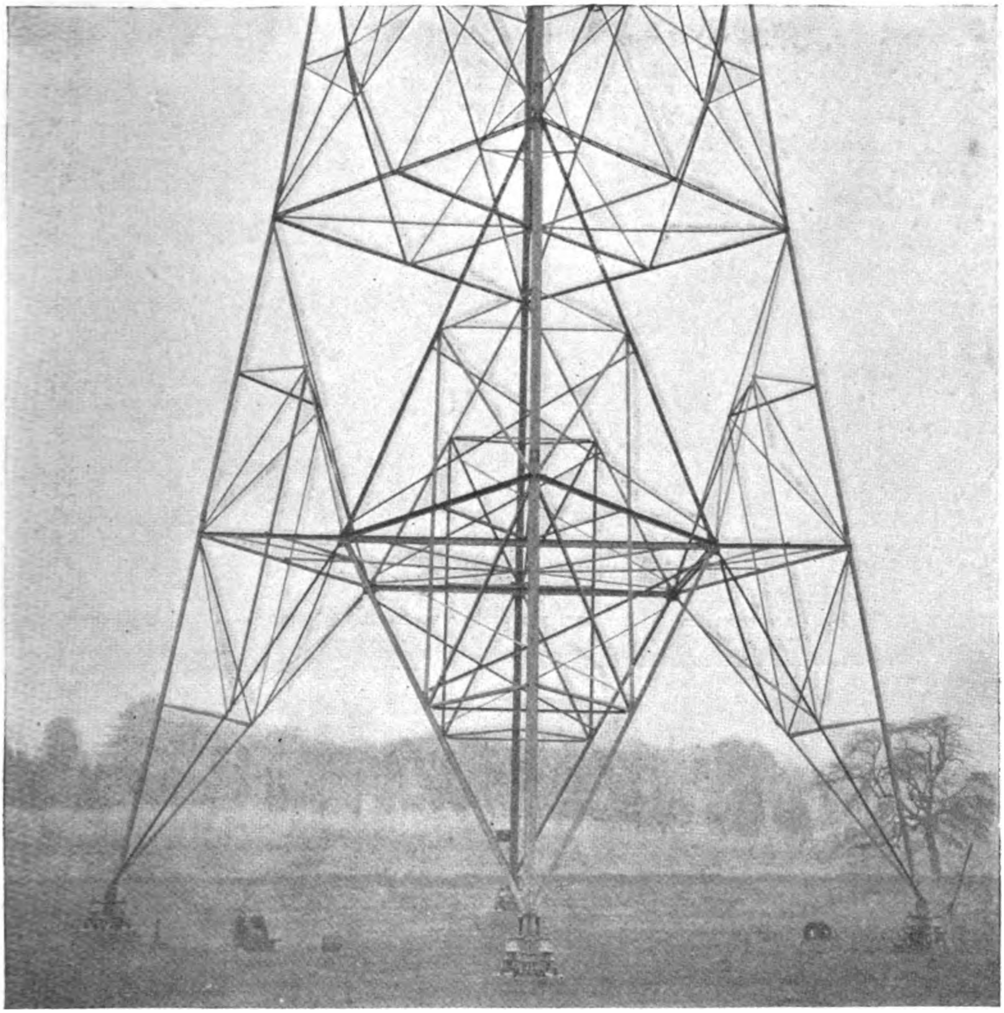
The transformer room where the outside current of 4300 volts potential is reduced to 2300 volts. One of the two motor generators is shown above.



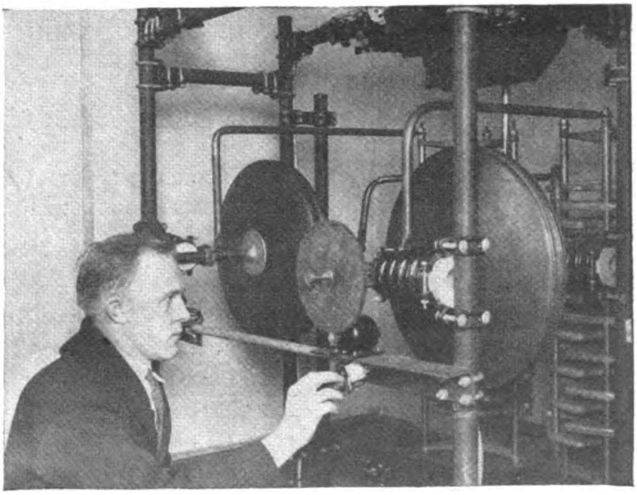
Four of the 64 ten-kilowatt tubes that are used in the station. The water-cooling jackets and tubing are here shown.



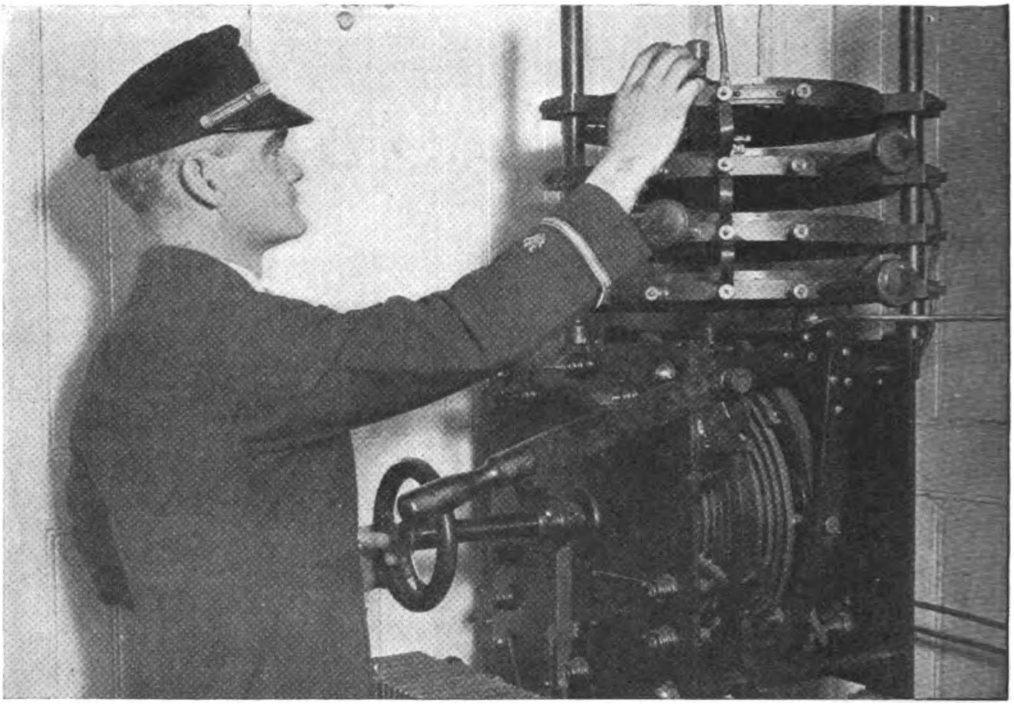
The huge water cooler which cools 100 gallons of water a minute. This water is kept constantly in circulation.



The steel network at the base of one of the two 400-foot towers which support the antenna. Notice how the feet of the tower are insulated from the ground.



A pair of vernier air condensers which are used to sharpen the antenna tuning. They are operated automatically by the tiny electric motor placed between them.



Kadel & Herbert

HOW A TRANSMITTING INDUCTANCE IS USED

The ship's operator in this picture is shown adjusting the variable "pancake" inductances of a quenched spark transmitter.

What "Inductance" Really Is

Article No. 15

Some of the main facts underlying the use of induction in modern electrical apparatus and some of the interesting phenomena that accompany the working of electrostatic and electromagnetic induction are told in this article.

By SIR OLIVER LODGE, F.R.S., D.Sc., LL.D.

"INDUCTION" is a general name that was first employed by Faraday to indicate any electromagnetic or electrostatic action across space; that is through the ether only, as opposed to "conduction" through matter.

When a charged body is brought near a conductor, it is said to act inductively on that conductor. If the conductor is insulated, its potential is thereby raised by an amount proportional to the charge and inversely as the distance of that charge.

Electrostatic Induction

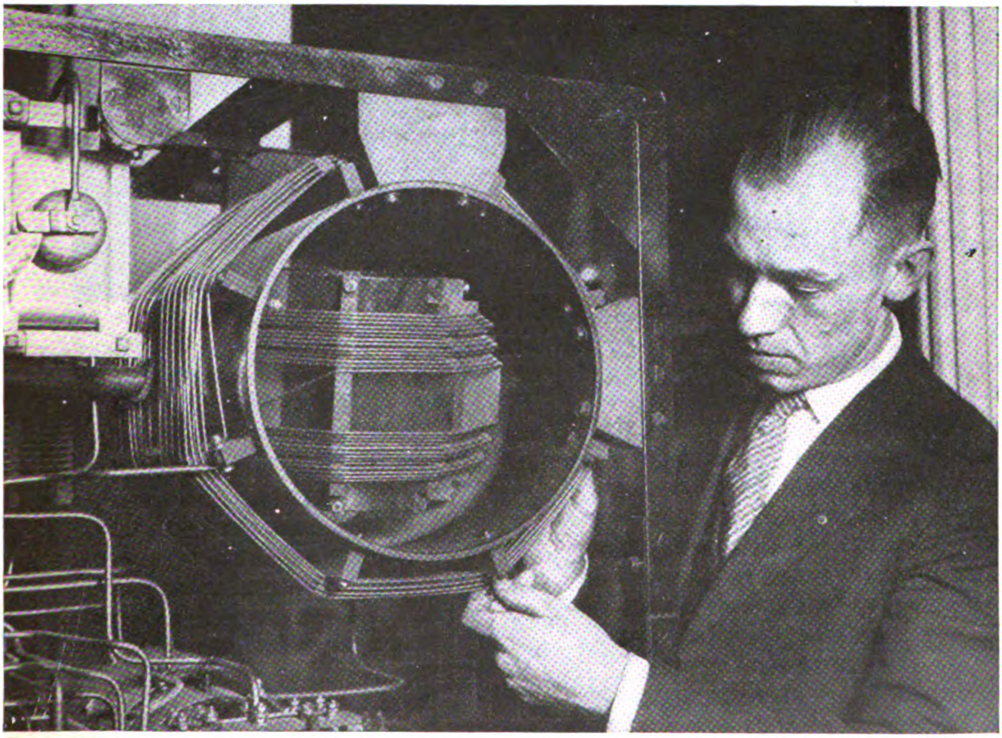
An insulated conductor thus acted upon inductively not only has its potential raised so that it can give off a spark similar in sign to that of the inducing body, but it has its own charges redistributed. The charge of the opposite sign is attracted towards the neighborhood of the inducing charge and a charge of similar sign is repelled, so that it has opposite charges at its two ends and is said to be polarized. If it is grounded the repelled charge escapes and an extra supply of the attracted sign is supplied sufficient to neutralize its potential and reduce it to zero in spite of the continued neighborhood of the inducing charge.

For instance, if a positively charged sphere is brought into a room, the floor, walls, ceiling, tables and all neighboring objects are charged inductively and negative electricity may be removed from any of them. If the hand of an operator is brought near the inducing charge that hand at once acquires an opposite charge.

In other words, electrons crowd into it from the earth and face the inducing positive charge until, if the hand be brought near enough and the potential of the inducing charge is high enough, the opposite charges rush together disruptively, breaking down the insulation of the air and causing the momentary evolution of heat and light called a spark.

If instead of a flat surface a pointed body is brought near the charge, the electrons crowding on to that point are able to break down the air at a considerable distance, giving however not a spark but a luminous glow (brush discharge). In other words, they electrify the air in the immediate neighborhood; which then, no doubt, moves towards the charged body and rapidly discharges it. In this way, what is called "an electric wind" (ionization) may be produced, which may drive a small paper-mill, or by its action on the point may propel that backwards, if it is free to move.

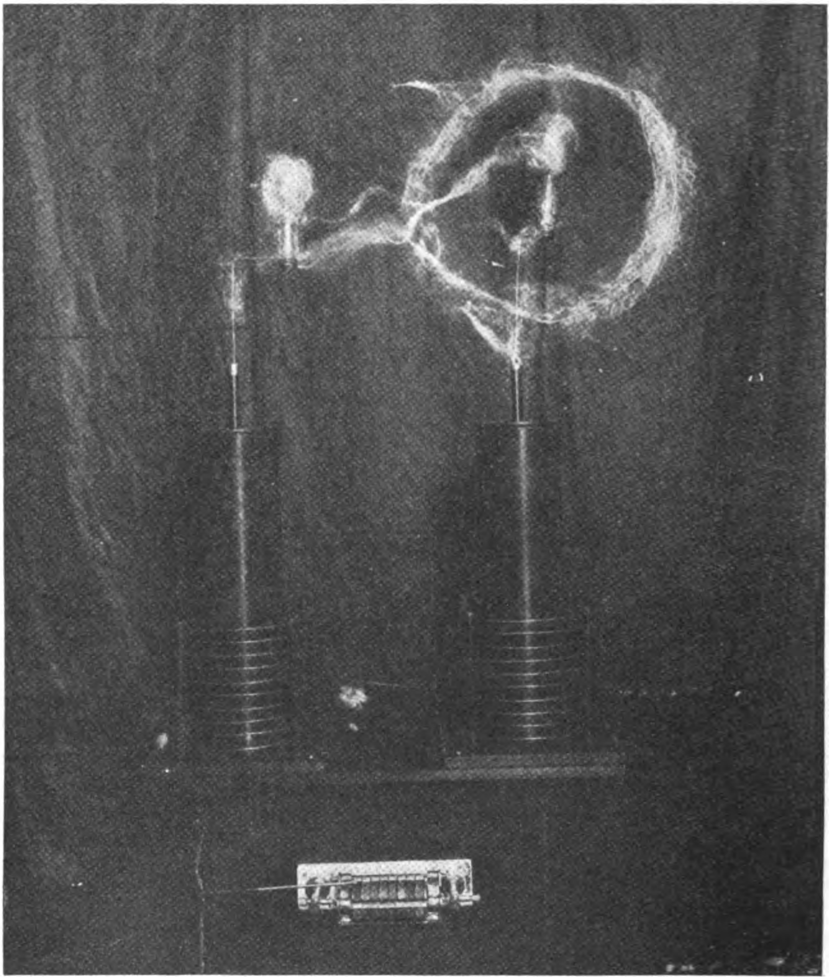
When an elongated insulated conductor is subjected to induction and then broken



Kadel & Herbert

A CONTINUOUSLY VARIABLE INDUCTANCE

The apparatus shown in this illustration is called a variometer. It consists of two coils of wire—an outer coil and an inner coil which is rotatable in inductive relation to the outer one. It is used in this case for transmitting.



Courtesy of Joseph G. Brand

THE TESLA-OUDIN INDUCTANCES

This apparatus also makes use of electromagnetic induction. The brushing discharge shown around the glass bulbs of the bent wires is produced by the use of the phenomenon known as induction.

in half or separated (by previous arrangement) into two portions, one half *will be charged negatively,* while the other half *will be charged positively.*

The two charges may be separated to any distance by what might be called "convection," though this term is more usually applied to the automatic carrying of charges by the atoms of matter, instead of to their artificial conveyance by hand or other means of locomotion.

Magnetic Induction

When one end of a long magnet, that is to say a magnetic pole, is brought near a piece of iron it too is acted on inductively and is said to be polarized.

If, for instance, the inducing pole is a north pole the piece of iron will have a south pole at the near end and a north pole at the far end. But if it is now broken in half these poles cannot be separated. New poles appear at the break and each half is a complete magnet. And the same will occur for as many pieces as are broken off.

This is an important distinction between magnetism and electricity. It may be said that whereas electric lines of force terminate on conductors, one end being positive, and the other end negative, magnetic lines of force never terminate but are always closed curves. However, when they quit the air and enter iron or steel, the change in what is called "magnetic permeability" or more simply, the change of material, causes poles to appear at the boundary. And these poles appear wherever there is a boundary.

Moreover, there is no ordinary conduction for magnetism, as there is for electricity, and a magnet cannot be discharged by touching it. Steel magnets may be magnetized by induction, and if the steel is hard they will retain the magnetism imparted. That is to say, the material does not allow the lines of force produced in it to subside again. A portion may subside but a portion is retained.

The retained portion is called "permanent magnetism."

It can, however, be got rid of in several ways. It partly subsides if the steel is rapped violently, as by the blows of a hammer. It also subsides to some extent with the lapse of time. It diminishes also if the steel is heated: at a certain temperature it disappears altogether. At a red-heat iron becomes insusceptible to magnetism. Nickel loses its susceptibility at a much lower temperature. Cobalt retains it to a white-heat.

Concerning the nature and cause of these differences, and indeed the reason for the susceptibility of iron and other magnetic substances, some progress has been made, but there is much still to be discovered. At present, in an elementary [illegible] must ascertain and accept the facts. Hard steel is not easily magnetized; but when it is magnetized it remains in a magnetized state, especially if the bar is long and thin. A short stout bar is quite unsuitable for a permanent magnet. If such a bar magnet is wanted, it should be made of thin bars separately magnetized and then riveted or clamped together.

Electricity may be conveyed from one body to another by conduction, but magnetism can only be transmitted by induction and the two opposite poles can never be separated. The poles of every magnet are equal in strength; though if they are of different size, one may be more concentrated than the other.

All the lines of force from every portion of the north pole curve round to a corresponding portion of the south pole and then continue through the steel or iron completing the magnetic circuit. Such a circuit is sometimes called "open" —meaning that it has an air-gap; in the case of a bar magnet a wide and diffuse air-gap. It may be technically closed, or short circuited, by a piece of iron or "keeper" so that the stray field in the air can be reduced to insignificance. But all magnetic circuits are really closed in one material or another.

The same statement may be made for "current" electricity, for when a current flows it must flow in a complete circuit. But if a dielectric or insulator is interposed in that circuit, then the circuit is completed, not by conduction, but by electric displacement. That is, it is completed in an elastic manner like the stretching of a membrane across a pipe, which would be displaced by the flow of water until it either bursts or stops the flow and causes an elastic recoil or discharge. That is just what happens in a condenser, though the displacement is not of a mechanical and obvious kind. The electric flow is checked and driven back again when the propelling force is removed and the external metallic circuit completed.

Some dielectrics are much more easily "burst" than others. Glass, bakelite, hard rubber and even liquid insulators, such as oil are able to stand a considerable strain. Air is burst more easily. Induction always precedes a spark; and it is electrostatic induction which chiefly operates in condensers as against electromagnetic induction in transformers.

Broadcasting Stations in the U. S.

(Corrected as of January 20, 1926)

Call Letters	Location	Wave-length
KDKA	East Pittsburg, Pa.	309.1
KDLR	Devils Lake, N. D.	231
KDYL	Salt Lake City, Utah	246
KDZB	Bakersfield, Cal.	209.7
KFAB	Lincoln, Neb.	340.7
KFAD	Phoenix, Ariz	273
KFAF	San Jose, Cal.	217.3
KFAJ	Boulder, Col.	261
KFAU	Boise, Ida	282.8
KFBB	Havre, Mont.	275
KFBC	San Diego, Cal.	224
KFBK	Sacramento, Cal.	248
KFBL	Everett, Wash.	224
KFBS	Trinidad, Col.	238
KFBU	Laramie, Wyo.	270
KFCB	Phoenix, Ariz.	238
KFCF	Walla Walla, Wash.	256
KFDD	Boise, Ida	278
KFDJ	Corvallis, Ore.	282.8
KFDM	Beaumont, Tex.	315.6
KFDX	Shreveport, La.	250
KFDY	Brookings, S. D.	273
KFDZ	Minneapolis, Minn.	231
KFEC	Portland, Ore.	248
KFEL	Denver, Col.	254
KFEQ	Oak, Neb.	268
KFEY	Kellogg, Ida.	233
KFFP	Moberly, Mo.	242
KFGH	Stanford University, Cal.	270
KFGQ	Boone, Ia.	226
KFH	Wichita, Kan.	268
KFHA	Gunnison, Col.	252
KFHL	Oskaloosa, Ia.	240
KFI	Los Angeles, Cal.	468.5
KFIF	Portland, Ore.	248
KFIO	Spokane, Wash.	266
KFIQ	Yakima, Wash	256
KFIU	Juneau, Alaska	226
KFIZ	Fondulac, Wis.	273
KFJB	Marshalltown, Ia.	248
KFJC	Junction City, Kan.	218.8
KFJF	Oklahoma City, Okla.	261
KFJI	Astoria, Ore.	246
KFJM	Grand Forks, N. D.	278
KFJR	Portland, Ore.	263
KFJY	Fort Dodge, Ia.	246
KFJZ	Fort Worth, Tex.	254
KFKA	Greeley, Col.	273
KFKU	Lawrence, Kan.	275
KFKX	Hastings, Neb.	288.3
KFKZ	Kirksville, Mo.	226
KFLR	Albuquerque, N. M.	254
KFLU	San Benito, Tex.	236
KFLV	Rockford, Ill.	229
KFLX	Galveston, Tex.	240
KFLZ	Anita, Ia.	273
KFMQ	Fayetteville, Ark.	299.8
KFMR	Sioux City, Ia.	261
KFMW	Houghton, Mich.	263
KFMX	Northfield, Minn.	336.9
KFNF	Shenandoah, Ia.	263
KFOA	Seattle, Wash.	454.3
KFOB	Burlingame, Cal.	226
KFOJ	Moberly, Mo.	242
KFON	Long Beach, Cal.	233
KFOO	Salt Lake City, Utah	236
KFOR	David City, Neb.	226
KFOT	Wichita, Kan.	231
KFOX	Omaha, Neb.	248
KFOY	St. Paul, Minn.	252
KFPL	Dublin, Tex.	252
KFPM	Greenville, Tex.	242
KFPR	Los Angeles, Cal.	231
KFPW	Carterville, Mo.	258
KFPY	Spokane, Wash.	266
KFQA	St. Louis, Mo.	261
KFQB	Fort Worth, Tex.	263
KFQP	Iowa City, Ia.	224
KFQU	Holy City, Cal.	217.3
KFQW	North Bend, Wash.	215.7
KFQZ	Hollywood, Cal.	226
KFRB	Beeville, Tex.	248
KFRC	San Francisco, Cal.	268

Location	Wave-length	Call Letters
AGRICULTURAL COL., N. D.	275	WPAK
AKRON, O.	258	WADC
ALBUQUERQUE, N. M.	254	KFLR
ALBUQUERQUE, N. M.	250	KFVY
ALLENTOWN, PA.	254	WCBA
ALLENTOWN, PA.	229	WSAN
ALTOONA, PA.	278	WFBG
AMARILLO, TEX.	263	WDAG
AMES, IA.	270	WOI
ANDERSON, IND.	246	WEBD
ANDERSON, IND.	218.8	WHBU
ANITA, IA.	273	KFLZ
ASHEVILLE, N. C.	254	WABC
ASTORIA, ORE.	246	KFJI
ATLANTA, GA.	270	WDBE
ATLANTA, GA.	270	WGST
ATLANTA, GA.	428.3	WSB
ATLANTIC CITY, N. J.	275	WHAR
ATLANTIC CITY, N. J.	299.8	WPG
AUBURN, ALA.	248	WAPI
AUSTIN, TEX.	231	KUT
AVALON, CAL.	211.1	KFWO
BAKERSFIELD, CAL.	209.7	KDZB
BALTIMORE, MD.	246	WBAL
BALTIMORE, MD.	275	WCAO
BALTIMORE, MD.	229	WCBM
BALTIMORE, MD.	254	WFBR
BANGOR, ME.	240	WABI
BATAVIA, ILL.	275	WORD
BAY CITY, MICH.	261	WSKC
BAY SHORE, N. Y.	215.7	WRST
BEAUMONT, TEX.	315.6	KFDM
BEAUMONT, TEX.	227	KFXM
BEEVILLE, TEX.	248	KFRB
BELLEFONTAINE, O.	222	WHBD
BELOIT, WIS.	268	WEBW
BERKELEY, CAL.	256	KRE
BERRIEN SPRINGS, MICH.	285.5	WEMC
BIG BEAR LAKE, CAL.	202.6	KFXB
BIRMINGHAM, ALA.	218	WBRC
BISMARCK, N. D.	248	KFYR
BOISE, IDA.	282.8	KFAU
BOISE, IDA.	278	KFDD
BOONE, IA.	226	KFGQ
BOSTON, MASS.	242	WBZA
BOSTON, MASS.	261	WDBR
BOSTON, MASS.	348.6	WEEI
BOSTON, MASS.	250	WNAB
BOSTON, MASS.	280.2	WNAC
BOULDER, COL.	261	KFAJ
BRISTOW, OKLA.	374.8	KVOO
BROOKINGS, S. D.	273	KFDY
BROOKLYN, N. Y.	205.4	WFRL
BROWNSVILLE, TEX.	278	KWWG
BUFFALO, N. Y.	244	WEBR
BUFFALO, N. Y.	319	WGR
BUFFALO, N. Y.	218.8	WJBP
BURLINGAME, CAL.	226	KFOB
BURLINGTON, IA.	254	WIAS
BURLINGTON, VT.	250	WCAX
CAMBRIDGE, ILL.	242	WTAP
CAMBRIDGE, O.	234	WEBE
CAMDEN, N. J.	236	WFBI
CAMP LAKE, WIS.	231	WCLO
CANTON, N. Y.	263	WCAD
CANTON, O.	254	WHBC
CAMP GIRARDEAU, MO.	224	KFVS
CARTERVILLE, MO.	258	KFPW
CARTHAGE, ILL.	236	WTAD
CAZENOVIA, N. Y.	275	WMAC
CEDAR RAPIDS, IA.	278	KWCR
CEDAR RAPIDS, IA.	268	WJAM
CHARLESTON, S. C.	268	WBBY
CHARLOTTE, N. C.	275	WBT
CHARLOTTE, N. C.	224	WJBG
CHATTANOOGA, TENN.	256	WDOD
CHICAGO, ILL.	535.4	KYW
CHICAGO, ILL.	278	WAAF
CHICAGO, ILL.	226	WBBM
CHICAGO, ILL.	215.7	WBBZ
CHICAGO, ILL.	266	WBCN
CHICAGO, ILL.	370.2	WEBH
CHICAGO, ILL.	266	WENR

Wave-length	Location	Call Letters
202.6	Big Bear Lake, Cal.	KFXB
202.6	Elizabeth, N. J.	WIBS
202.6	Evanston, Ill.	WEHS
205.4	Brooklyn, N.Y.	WFRL
205.4	Flagstaff Ariz.	KFXY
205.4	Logan, Utah	KFXD
205.4	Oxnard, Cal.	KFYF
205.4	Providence, R. I.	WCBR
205.4	San Pedro, Cal.	KFVD
205.4	Utica, N. Y.	WIBX
206.8	Joliet, Ill.	WJBA
206.8	Oakland, Cal.	KFWM
206.8	Wooster, O.	WABW
208.2	Los Angeles, Cal.	KNRC
209.7	Bakersfield, Cal.	KDZB
209.7	Chicago, Ill.	WSBC
209.7	New Bedford, Mass.	WIBH
209.7	New York, N. Y.	WBNY
209.7	Providence, R. I.	WCWS
209.7	Santa Maria, Cal.	KFXC
211.1	Avalon, Cal.	KFWO
211.1	Lewisburg, Pa.	WJBQ
211.1	Upland, Cal.	KFWC
212.6	Portland, Ore.	KFWV
212.6	Portland, Ore.	KQP
212.6	Richmond Hill, N. Y.	WWGL
212.6	Washington, D. C.	WMAL
214.2	Joliet, Ill.	WCLS
214.2	Joliet, Ill.	WKBB
214.2	Oklahoma City, Okla.	KFXR
214.2	St. Louis, Mo.	KFWF
215.7	Bay Shore, N. Y.	WRST
215.7	Chicago, Ill.	WBBZ
215.7	Chicago, Ill.	WIBJ
215.7	Chicago, Ill.	WIBM
215.7	Chicago, Ill.	WKBG
215.7	Denver, Col.	KFXJ
215.7	Harrisburg, Pa.	WPRC
215.7	Logansport, Ind.	WHBL
215.7	North Bend, Wash.	KFQW
215.7	Philadelphia, Pa.	WHBW
217.3	Chicago, Ill.	WFKV
217.3	Holy City, Cal.	KFQU
217.3	Homewood, Ill.	WOK
217.3	San Jose, Cal.	KFAF
218.8	Anderson, Ind.	WHBU
218.8	Buffalo, N. Y.	WJBP
218.8	Flushing, N. Y.	WIBI
218.8	Junction City, Kan.	KFJC
218.8	Manhattan, Kan.	KFVH
218.8	Olympia, Wash.	KFRW
218.8	Red Bank, N. J.	WJBI
220	Logansport, Ind.	WIBW
220	Oakland, Cal.	KFUU
220	Parkerburg, Pa.	WQAA
220	San Francisco, Cal.	KJBS
222	Bellefontaine, O.	WHBD
222	Culver, Ind.	WHBH
222	Elkins Park Pa.	WIBG
222	Norfolk, Va.	WBBW
222	Poynette, Wis.	WIBU
222	Rock Island, Ill.	WHBF
222	St. Petersburg, Fla.	WIBC
222	Takoma Park, Md.	WBES
224	Cape Girardeau, Mo.	KFVS
224	Charlotte, N. C.	WJBG
224	Everett, Wash.	KFBL
224	Iowa City, Ia.	KFQP
224	Laconia, N. H.	WKAV
224	Monmouth, Ill.	WBBU
224	Ogden, Utah	KFUR
224	Paterson, N. J.	WODA
224	San Diego, Cal.	KFBC
226	Boone, Ia.	KFGQ
226	Burlingame, Cal.	KFOB
226	Chicago, Ill.	WBBM
226	Chicago, Ill.	WIBO
226	David City, Neb.	KFOR
226	Harrisburg, Ill.	WEBQ
226	Hollywood, Cal.	KFQZ
226	Juneau, Alaska	KFIU
226	Kirksville, Mo.	KFKZ
226	Nashville, Tenn.	WDAD

Call Letters	Location	Wave-length
KFRU	Columbia, Mo.	499.7
KFRW	Olympia, Wash.	218.8
KFSG	Los Angeles, Cal.	275
KFUL	Galveston, Tex.	258
KFUO	St. Louis, Mo.	545.1
KFUP	Denver, Col.	234
KFUR	Ogden, Utah	224
KFUS	Oakland, Cal.	256
KFUT	Salt Lake City, Utah	261
KFUU	Oakland, Cal.	220
KFVD	San Pedro, Cal.	205.4
KFVE	St. Louis, Mo.	240
KFVG	Independence, Kan.	236
KFVH	Manhattan, Kan.	218.8
KFVI	Houston, Tex.	240
KFVN	Welcome, Minn.	227
KFVR	Denver, Col.	244
KFVS	Cape Girardeau, Mo.	224
KFVW	San Diego, Cal.	246
KFVY	Albuquerque, N. M.	250
KFWA	Ogden, Utah	261
KFWB	Hollywood, Cal.	252
KFWC	Upland, Cal.	211.1
KFWF	St. Louis, Mo.	214.2
KFWH	Chico, Cal.	254
KFWI	South San Francisco, Cal.	226
KFWM	Oakland, Cal.	206.8
KFWO	Avalon, Cal.	211.1
KFWU	Pineville, La.	238
KFWV	Portland, Ore.	212.6
KFXB	Big Bear Lake, Cal.	202.6
KFXC	Santa Maria, Cal.	209.7
KFXD	Logan, Utah	205.4
KFXF	Colorado Springs, Col.	250
KFXH	El Paso, Tex.	242
KFXJ	Denver, Col.	215.7
KFXM	Beaumont, Tex.	227
KFXR	Oklahoma City, Okla.	214.2
KFXY	Flagstaff, Ariz.	205.4
KFYF	Oxnard, Cal.	205.4
KFYJ	Houston, Tex.	238
KFYR	Bismark, N. D.	248
KGO	Oakland, Cal.	361.2
KGTT	San Francisco, Cal.	234
KGU	Honolulu, Hawaii	270
KGW	Portland, Ore.	491.5
KGY	Lacey, Wash.	246
KHJ	Los Angeles, Cal.	405.2
KHQ	Spokane, Wash.	273
KJBS	San Francisco, Cal.	220
KJR	Seattle, Wash.	384.4
KLDS	Independence, Mo.	440.9
KLS	Oakland, Cal.	250
KLX	Oakland, Cal.	508.2
KLZ	Denver, Col.	266
KMA	Shenandoah, Ia.	252
KMJ	Fresno, Cal.	234
KMMJ	Clay Center, Neb.	229
KMO	Tacoma, Wash.	250
KMOX	St. Louis, Mo.	233
KMTR	Los Angeles, Cal.	238
KNRC	Los Angeles, Cal.	208.2
KNX	Hollywood, Cal.	336.9
KOA	Denver, Col.	322.4
KOB	State College, N. M.	348.6
KOCH	Omaha, Neb.	258
KOCW	Chickasha, Okla.	252
KOIL	Council Bluffs, Ia.	278
KPO	San Francisco, Cal.	428.3
KPPC	Pasadena, Cal.	229
KPRC	Houston, Tex.	296.9
KPSN	Pasadena, Cal.	315.6
KQP	Portland, Ore.	212.6
KQV	Pittsburg, Pa.	275
KQW	San Jose, Cal.	231
KRE	Berkeley, Cal.	256
KSAC	Manhattan, Kan.	340.7
KSD	St. Louis, Mo.	545.1
KSL	Salt Lake City, Utah	299.8
KSO	Clarinda, Ia.	242
KTAB	Oakland, Cal.	240
KTBI	Los Angeles, Cal.	293.9
KTBR	Portland, Ore.	263
KTCL	Seattle, Wash.	305.9
KTHS	Hot Springs, Ark.	374.8
KTNT	Muscatine, Ia.	256
KTW	Seattle, Wash.	454.3
KUO	San Francisco, Cal.	250

Location	Wave-length	Call Letters
CHICAGO, ILL.	217.3	WFKB
CHICAGO, ILL.	302.8	WGN
CHICAGO, ILL.	233	WHBM
CHICAGO, ILL.	215.7	WIBJ
CHICAGO, ILL.	215.7	WIBM
CHICAGO, ILL.	226	WIBO
CHICAGO, ILL.	215.7	WKBG
CHICAGO, ILL.	258	WLTS
CHICAGO, ILL.	447.5	WMAQ
CHICAGO, ILL.	250	WMBB
CHICAGO, ILL.	258	WPCC
CHICAGO, ILL.	447.5	WQJ
CHICAGO, ILL.	268	WSAX
CHICAGO, ILL.	209.7	WSBC
CHICKASHA, OKLA.	252	KOCW
CHICO, CAL.	254	KFWH
CINCINNATI, O.	258	WAAD
CINCINNATI, O.	422.3	WKRC
CLARINDA, IA.	242	KSO
CLAY CENTER, NEB.	229	KMMJ
CLEARWATER, FLA.	266	WGHB
CLEVELAND, O.	227	WDBK
CLEVELAND, O.	389.4	WEAR
CLEVELAND, O.	273	WHK
CLEVELAND, O.	389.4	WTAM
COLDWATER, MISS.	254	WREC
COLLEGE STATION, TEX.	270	WTAW
COLLEGEVILLE, MINN.	236	WFBJ
COLORADO SPRINGS, COL.	250	KFXF
COLUMBIA, MO.	499.7	KFRU
COLUMBUS, O.	293.9	WAIU
COLUMBUS, O.	293.9	WEAO
COLUMBUS, O.	278	WMAN
CORVALLIS, ORE.	282.8	KFDJ
COUNCIL BLUFFS, IA.	278	KOIL
CRANSTON, R. I.	440.9	WDWF† WLSI
CRETE, ILL.	344.6	WLS
CULVER, IND.	222	WHBH
DALLAS, TEX.	475.9	WFAA
DALLAS, TEX.	246	WRR
DARTMOUTH, MASS.	440.9	WMAF
DAVENPORT, IA.	483.6	WOC
DAVID CITY, NEB.	226	KFOR
DAYTON, O.	275	WSMK
DEARBORN, MICH.	266	WWI
DECATUR, ILL.	270	WBAO
DECATUR, ILL.	270	WJBL
DEERFIELD, ILL.	238	WHT
DENVER, COL.	254	KFEL
DENVER, COL.	234	KFUP
DENVER, COL.	244	KFVR
DENVER, COL.	215.7	KFXJ
DENVER, COL.	266	KLZ
DENVER, COL.	322.4	KOA
DES MOINES, IA.	526	WHO
DETROIT, MICH.	270	WGHP
DETROIT, MICH.	256	WMBC
DETROIT, MICH.	352.7	WWJ
DEVIL'S LAKE, N. D.	231	KDLR
DUBLIN, TEX.	252	KFPL
EAST LANSING, MICH.	285.5	WKAR
EAST PITTSBURG, PA.	309.1	KDKA
ELGIN, ILL.	275	WCEE
ELGIN, ILL.	302.8	WLIB
ELIZABETH, N. J.	202.6	WIBS
ELKINS PARK, PA.	222	WIBG
ELLSWORTH, ME.	231	WHBK
EL PASO, TEX.	242	KFXH
EL PASO, TEX.	268	WDAH
ESCANABA, MICH.	256	WRAK
EVANSTON, ILL.	202.6	WEHS
EVANSVILLE, IND.	236	WGBF
EVERETT, WASH.	224	KFBL
FALL RIVER, MASS.	254	WSAR
FALL RIVER, MASS.	266	WTAB
FARGO, N. D.	261	WDAY
FAYETTEVILLE, ARK.	299.8	KFMQ
FLAGSTAFF, ARIZ.	205.4	KFXY
FLINT, MICH.	234	WFDF
FLUSHING, N. Y.	218.8	WIBI
FONDULAC, WIS.	273	KFIZ
FORT DODGE, IA.	246	KFJY
FORT WAYNE, IND.	234	WHBJ
FORT WAYNE, IND.	227	WOWO
FORT WORTH, TEX.	254	KFJZ
FORT WORTH, TEX.	263	KFQB
FORT WORTH, TEX.	475.9	WBAP

Wave-length	Location	Call Letters
226	New York, N. Y.	WEBL
226	New York, N. Y.	WEBM
226	Seymour, Ind.	WFBE
226	South San Francisco, Cal.	KFWI
227	Beaumont, Tex.	KFXM
227	Cleveland, O.	WDBK
227	Fort Wayne, Ind.	WOWO
227	Welcome, Minn.	KFVN
229	Allentown, Pa.	WSAN
229	Baltimore, Md.	WCBM
229	Clay Center, Neb.	KMMJ
229	Grove City, Pa.	WSAJ
229	Marshfield, Wis.	WGBR
229	Pasadena, Cal.	KPPC
229	Richmond, Va.	WBBL
229	Roanoke, Va.	WDBJ
229	Rockford, Ill.	KFLV
229	Taunton, Mass.	WAIT
231	Austin, Tex.	KUT
231	Camp Lake, Wis.	WCLO
231	Devils Lake, N. D.	KDLR
231	Ellsworth, Me.	WHBK
231	Harrisburg, Pa.	WHBG
231	Los Angeles, Cal.	KFPR
231	Minneapolis, Minn.	KFDZ
231	Montgomery, Ala.	WIBZ
231	San Jose, Cal.	KQW
231	Streator, Ill.	WTAX
231	Webster, Mass.	WKBE
231	Wichita, Kan.	KFOT
231	Wilkes-Barre, Pa.	WBRE
233	Chicago, Ill.	WHBM
233	Kellogg, Ida.	KFEY
233	Kingston, N. Y.	WDBZ
233	Long Beach, Cal.	KFON
233	Memphis, Tenn.	WHBQ
233	New York, N. Y.	WOKO
233	St. Louis, Mo.	KMOX
233	Ypsilanti, Mich.	WJBK
234	Cambridge, O.	WEBE
234	Denver, Col.	KFUP
234	Flint, Mich.	WFDF
234	Forty Wayne, Ind.	WHBJ
234	Fresno, Cal.	KMJ
234	La Salle, Ill.	WJBC
234	Philadelphia, Pa.	WFBD
234	Providence, R. I.	WGBM
234	San Francisco, Cal.	KGTT
236	Camden, N. J.	WFBI
236	Carthage, Ill.	WTAD
236	Collegeville, Minn.	WFBJ
236	Evansville, Ind.	WGBF
236	Independence, Kan.	KFVG
236	Kansas City, Mo.	KWKC
236	Madison, Wis.	WIBA
236	Nashville, Tenn.	WCBQ
236	New York, N. Y.	WRMU
236	Richmond Hill, N. Y.	WBOQ
236	Richmond Hill, N. Y.	WGMU
236	Salt Lake City, Utah	KFOO
236	San Benito, Tex.	KFLU
238	Deerfield, Ill.	WHT
238	Houston, Tex.	KFYJ
238	Los Angeles, Cal.	KMTR
238	Petoskey, Mich.	WBBP
238	Phoenix, Ariz.	KFCB
238	Pineville, La.	KFWU
238	Reading, Pa.	WRAW
238	St. Petersburg, Fla.	WHBN
238	Trinidad, Col.	KFBS
240	Bangor, Me.	WABI
240	Galveston, Tex.	KFLX
240	Houston, Tex.	KFVI
240	New York, N. Y.	WHAP
240	Oakland, Cal.	KTAB
240	Oakland, Cal.	KZM
240	Oskaloosa, Ia.	KFHL
240	Owosso, Mich.	WSMH
240	Rapid City, S. D.	WCAT
240	St. Louis, Mo.	KFVE
240	Scranton, Pa.	WGBI
240	Trenton, N. J.	WOAX
240	Winter Park, Fla.	WDBO
242	Boston, Mass.	WBZA
242	Cambridge, Ill.	WTAP
242	Clarinda Ia.	KSO
242	El Paso, Tex.	KFXH
242	Grand Rapids, Mich.	WEBK

Call Letters	Location	Wave-length
KUOM	Missoula, Mont.	244
KUSD	Vermillion, S. D.	278
KUT	Austin, Tex.	231
KVOO	Bristow, Okla.	374.8
KWCR	Cedar Rapids, Ia.	278
KWG	Stockton, Cal.	248
KWKC	Kansas City, Mo.	236
KWKH	Kennonwood, La.	261
KWSC	Pullman, Wash.	348.6
KWWG	Brownsville, Tex.	278
KYW	Chicago, Ill.	535.4
KZM	Oakland, Cal.	240
WAAD	Cincinnati, O.	258
WAAF	Chicago, Ill.	278
WAAW	Omaha, Neb.	278
WABC	Asheville, N. C.	254
WABI	Bangor, Me.	240
WABO	Rochester, N Y.	278
WABQ	Haverford, Pa.	261
WABR	Toledo, O.	263
WABW	Wooster, O.	206.8
WABX	Mt. Clemens, Mich.	246
WABY	Philadelphia, Pa.	242
WABZ	New Orleans, La.	275
WADC	Akron, O.	258
WAFD	Port Huron, Mich.	275
WAGM	Royal Oak, Mich.	258
WAHG	Richmond Hill, N. Y.	315.6
WAIT	Taunton, Mass.	229
WAIU	Columbus, O.	293.9
WAMD	Minneapolis, Minn.	244
WAPI	Auburn, Ala.	248
WARC	Medford, Mass.	261
WBAA	West Lafayette, Ind.	273
WBAK	Harrisburg, Pa.	275
WBAL	Baltimore, Md.	246
WBAO	Decatur, Ill.	270
WBAP	Fort Worth, Tex.	475.9
WBAX	Wilkes-Barre, Pa.	256
WBBL	Richmond, Va.	229
WBBM	Chicago, Ill.	226
WBBP	Petoskey, Mich.	238
WBBR	Rossville, N. Y.	273
WBBS	New Orleans, La.	252
WBBW	Norfolk, Va.	222
WBBY	Charleston, S. C.	268
WBBZ	Chicago, Ill.	215.7
WBCN	Chicago, Ill.	266
WBDC	Grand Rapids, Mich.	256
WBES	Takoma Park, Md.	222
WBNY	New York, N. Y.	209.7
WBOQ	Richmond Hill, N. Y.	236
WBRC	Birmingham, Ala.	248
WBRE	Wilkes-Barre, Pa.	231
WBT	Charlotte, N. C.	275
WBZ	Springfield, Mass.	333.1
WBZA	Boston, Mass.	242
WCAC	Mansfield, Conn.	275
WCAD	Canton, N. Y.	263
WCAE	Pittsburg, Pa.	461.3
WCAJ	University Place, Neb.	254
WCAL	Northfield, Minn.	336.9
WCAO	Baltimore, Md.	275
WCAP	Washington, D. C.	468.5
WCAR	San Antonio, Tex.	263
WCAT	Rapid City, S. D.	240
WCAU	Philadelphia, Pa.	278
WCAX	Burlington, Vt.	250
WCBA	Allentown, Pa.	254
WCBD	Zion, Ill.	344.6
WCBE	New Orleans, La.	263
WCBH	Oxford, Miss.	242
WCBM	Baltimore, Md.	229
WCBQ	Nashville, Tenn.	236
WCBR	Providence, R. I.	205.4
WCCO	St. Paul-Minneapolis, Minn.	416.4
WCEE	Elgin, Ill.	275
WCLO	Camp Lake, Wis.	231
WCLS	Joliet, Ill.	214.2
WCSH	Portland, Me.	256
WCSO	Springfield, O.	248
WCWS	Providence, R. I.	209.7
WCX	Pontiac, Mich.	516.9
WDAD	Nashville, Tenn.	226
WDAE	Tampa, Fla.	273
WDAF	Kansas City, Mo.	365.6
WDAG	Amarillo, Tex.	263
WDAH	El Paso, Tex.	268

Location	Wave-length	Call Letters
FREEPORT, N. Y.	244	WGBB
FRESNO, CAL.	234	KMJ
FULFORD-BY-THE-SEA, FLA.	278	WGBU
GALESBURG, ILL.	254	WFBZ
GALESBURG, ILL.	244	WRAM
GALVESTON, TEX.	240	KFLX
GALVESTON, TEX.	258	KFUL
GLOUCESTER CITY, N. J.	268	WRAX
GRAND FORKS, N. D.	278	KFJM
GRAND RAPIDS, MICH.	256	WBDC
GRAND RAPIDS, MICH.	242	WEBK
GREELEY, COL.	273	KFKA
GREENTOWN, IND.	254	WJAK
GREENVILLE, TEX.	242	KFPM
GROVE CITY, PA.	229	WSAJ
GUNNISON, COL.	252	KFHA
HAMILTON, O.	270	WRK
HAMILTON, O.	252	WSRO
HANOVER, N. H.	256	WDCH
HARRISBURG, ILL.	226	WEBQ
HARRISBURG, PA.	275	WBAK
HARRISBURG, PA.	231	WHBG
HARRISBURG, PA.	215.7	WPRC
HARRISON, O.	422.3	WLW
HARTFORD, CONN.	475.9	WTIC
HASTINGS, NEB.	288.3	KFKX
HAVERFORD, PA.	261	WABQ
HAVRE, MONT.	275	KFBB
HOBOKEN, N. J.	340.7	WMCA
HOLLYWOOD, CAL.	226	KFQZ
HOLLYWOOD, CAL.	252	KFWB
HOLLYWOOD, CAL.	336.9	KNX
HOLY CITY, CAL.	217.3	KFQU
HOMEWOOD, ILL.	217.3	WOK
HONOLULU, HAWAII	270	KGU
HOT SPRINGS, ARK.	374.8	KTHS
HOUGHTON, MICH.	263	KFMW
HOUGHTON, MICH.	263	WWAO
HOUSTON, TEX.	240	KFVI
HOUSTON, TEX.	238	KFYJ
HOUSTON, TEX.	296.9	KPRC
INDEPENDENCE, KAN.	236	KFVG
INDEPENDENCE, MO.	440.9	KLDS
INDIANAPOLIS, IND.	268	WFBM
IOWA CITY, IA.	224	KFQP
IOWA CITY, IA.	483.6	WSUI
ITHACA, N. Y.	254	WEAI
JACKSONVILLE, FLA.	336.9	WJAX
JAMESTOWN, N. Y.	275	WOCL
JEFFERSON CITY, MO.	440.9	WOS
JOHNSTOWN, PA.	256	WHBP
JOHNSTOWN, PA.	248	WGBK
JOHNSTOWN, PA.	268	WTAC
JOLIET, ILL.	214.2	WCLS
JOLIET, ILL.	206.8	WJBA
JOLIET, ILL.	214.2	WKBB
JUNCTION CITY, KAN.	218.8	KFJC
JUNEAU, ALASKA	226	KFIU
KANSAS CITY, MO.	236	KWKC
KANSAS CITY, MO.	365.6	WDAF
KANSAS CITY, MO.	365.6	WHB
KANSAS CITY, MO.	278	WOQ
KELLOGG, IDA.	233	KFEY
KENNONWOOD, LA.	261	KWKH
KINGSTON, N. Y.	233	WDBZ
KIRKSVILLE, MO.	226	KFKZ
KNOXVILLE, TENN.	250	WFBC
KNOXVILLE, TENN.	268	WNOX
LACEY, WASH.	246	KGY
LACONIA, N. H.	224	WKAV
LAMBERTVILLE, N. J.	261	WTAZ
LANCASTER, PA.	258	WDBC
LANCASTER, PA.	248	WGAL
LANSING, MICH.	285.5	WREO
LAPORTE, IND.	224	WRAF
LARAMIE, WYO.	270	KFBU
LA SALLE, ILL.	234	WJBC
LAWRENCE, KAN.	275	KFKU
LAWRENCEBURG, TENN.	282.8	WOAN
LEWISBURG, PA.	211.1	WJBQ
LINCOLN, NEB.	340.7	KFAB
LINCOLN, NEB.	275	WFAV
LOCKPORT, N. Y.	266	WMAK
LOGAN, UTAH	205.4	KFXD
LOGANSPORT, IND.	215.7	WHBL
LOGANSPORT, IND.	220	WIBW
LONG BEACH, CAL.	233	KFON
LOS ANGELES, CAL.	468.5	KFI

Wave-length	Location	Call Letters
242	Greenville, Tex.	KFPM
242	Moberly, Mo.	KFFJ
242	Moberly, Mo.	KFOP
242	Oxford, Miss.	WCBH
242	Philadelphia, Pa.	WABY
242	Plainfield, Ill.	WWAE
242	Superior, Wis.	WEBC
244	Buffalo, N. Y.	WEBR
244	Denver, Col.	KFVR
244	Freeport, N. Y.	WGBB
244	Galesburg, Ill.	WRAM
244	Minneapolis, Minn.	WAMD
244	Missoula, Mont.	KUOM
244	Pomeroy, O.	WSAZ
244	Yankton, S. D.	WNAX
246	Anderson, Ind.	WEBD
246	Astoria, Ore.	KFJI
246	Baltimore, Md.	WBAL
246	Dallas, Tex.	WRR
246	Fort Dodge, Ia.	KFJY
246	Lacey, Wash.	KGY
246	Milwaukee, Wis.	WSOE
246	Mt. Clemens, Mich.	WABX
246	Salt Lake City, Utah	KDYL
246	San Diego, Cal.	KFVW
246	Springfield, Vt.	WQAE
246	Weirton, W. Va.	WIBR
248	Auburn, Ala.	WAPI
248	Beeville, Tex.	KFRB
248	Birmingham, Ala.	WBRC
248	Bismark, N. D.	KFYR
248	Johnstown, Pa.	WGBK
248	Lancaster, Pa.	WGAL
248	Marshalltown, Ia.	KFJB
248	New Bedford, Mass.	WNBH
248	Omaha, Neb.	KFOX
248	Portland, Ore.	KFEC
248	Portland, Ore.	KFIF
248	Sacramento, Cal.	KFBK
248	St.Louis, Mo.	WEW
248	St. Louis, Mo.	WMAY
248	Springfield, O.	WCSO
248	Stockton, Cal.	KWG
248	West Palm Beach, Fla.	WIOD
250	Albuquerque, N. M.	KFVY
250	Boston, Mass.	WNAB
250	Burlington, Vt.	WCAX
250	Chicago, Ill.	WMBB
250	Colorado Springs, Col.	KFXF
250	Knoxville, Tenn.	WFBC
250	Oakland, Cal.	KLS
250	Oak Park, Ill.	WGES
250	Oil City, Pa.	WHBA
250	Philadelphia, Pa.	WIAB
250	Philadelphia, Pa.	WNAT
250	Philadelphia, Pa.	WWAD
250	San Francisco, Cal.	KUO
250	Scranton, Pa.	WQAN
250	Shreveport, La.	KFDX
250	Tacoma, Wash.	KMO
250	Tulsa, Okla.	WLAL
252	Chickasha, Okla.	KOCW
252	Dublin, Tex.	KFPL
252	Gunnison, Col.	KFHA
252	Hamilton, O.	WSRO
252	Hollywood, Cal.	KFWB
252	Minneapolis, Minn.	WRHM
252	Newark, N. J.	WNJ
252	Newark, N. J.	WGCP
252	New Orleans, La.	WBBS
252	Orono, Me.	WGBX
252	Raleigh, N. C.	WRCO
252	St. Paul, Minn.	KFOY
252	Shenandoah, Ia.	KMA
252	Syracuse, N. Y.	WFBL
252	Toledo, O.	WTAL
254	Alburquerque, N. M.	KFLR
254	Allentown, Pa.	WCBA
254	Asheville, N. C.	WABC
254	Baltimore, Md.	WFBR
254	Burlington, Ia.	WIAS
254	Canton, O.	WHBC
254	Chico, Cal.	KFWH
254	Coldwater, Miss.	WREC
254	Denver, Col.	KFEL
254	Fall River, Mass.	WSAR
254	Fort Worth, Tex.	KFJZ
254	Galesburg, Ill.	WFBZ

Call Letters	Location	Wave-length
WDAY	Fargo, N. D.	261
WDBC	Lancaster, Pa.	258
WDBE	Atlanta, Ga.	270
WDBJ	Roanoke, Va.	229
WDBK	Cleveland, O.	227
WDBO	Winter Park, Fla.	240
WDBR	Boston, Mass.	261
WDBZ	Kingston, N. Y.	233
WDCH	Hanover, N. H.	256
WDOD	Chattanooga, Tenn.	256
WDRC	New Haven, Conn.	268
WDWF	Cranston, R. I.	440.9
WDZ	Tuscola, Ill.	278
WEAF	New York, N. Y.	491.5
WEAI	Ithaca, N. Y.	254
WEAM	North Plainfield, N. J.	261
WEAN	Providence, R. I.	270
WEAO	Columbus, O.	293.9
WEAR	Cleveland, O.	389.4
WEAU	Sioux City, Ia.	275
WEBC	Superior, Wis.	242
WEBD	Anderson, Ind.	246
WEBE	Cambridge, O.	234
WEBH	Chicago, Ill.	370.2
WEBJ	New York, N. Y.	273
WEBK	Grand Rapids, Mich.	242
WEBL	New York, N. Y.	226
WEBM	New York, N. Y.	226
WEBQ	Harrisburg, Ill.	226
WEBR	Buffalo, N. Y.	244
WEBW	Beloit, Wis.	268
WEBZ	Savannah, Ga.	263
WEEI	Boston, Mass.	348.6
WEHS	Evanston, Ill.	202.6
WEMC	Berrien Springs, Mich.	285.5
WENR	Chicago, Ill.	266
WEPI	Newark, N. J.	263
WEW	St. Louis, Mo.	248
WFAA	Dallas, Tex.	475.9
WFAM	St. Cloud, Minn.	273
WFAV	Lincoln, Neb.	275
WFBC	Knoxville, Tenn.	250
WFBD	Philadelphia, Pa.	234
WFBE	Seymour, Ind.	226
WFBG	Altoona, Pa.	278
WFBH	New York, N. Y.	273
WFBI	Camden, N. J.	236
WFBJ	Collegeville, Minn.	236
WFBL	Syracuse, N. Y.	252
WFBM	Indianapolis, Ind.	268
WFBR	Baltimore, Md.	254
WFBZ	Galesburg, Ill.	254
WFDF	Flint, Mich.	234
WFI	Philadelphia, Pa.	394.5
WFKB	Chicago, Ill.	217.3
WFRL	Brooklyn, N Y.	205 4
WGAL	Lancaster, Pa.	248
WGBB	Freeport, N. Y.	244
WGBC	Memphis, Tenn.	278
WGBF	Evansville, Ind.	236
WGBI	Scranton, Pa.	240
WGBK	Johnstown, Pa.	248
WGBM	Providence, R. I.	234
WGBR	Marshfield, Wis.	229
WGBS	New York, N. Y.	315.6
WGBU	Fulford-by-the-Sea, Fla.	278
WGBX	Orono, Me.	252
WGCP	Newark, N. J.	252
WGES	Oak Park, Ill.	250
WGHB	Clearwater, Fla.	266
WGHP	Detroit, Mich.	270
WGMU	Richmond Hill, N. Y.	236
WGN	Chicago, Ill.	302.8
WGR	Buffalo, N. Y.	319
WGST	Atlanta, Ga.	270
WGY	Schenectady	379.5
WHA	Madison, Wis.	535.4
WHAD	Milwaukee, Wis.	275
WHAM	Rochester, N. Y.	278
WHAP	New York, N. Y.	240
WHAR	Atlantic City, N. J.	275
WHAS	Louisville, Ky.	399.8
WHAT	Minneapolis, Minn.	263
WHAV	Wilmington, Del.	266
WHAZ	Troy, N. Y.	379.5
WHB	Kansas City, Mo.	365.6
WHBA	Oil City, Pa.	250
WHBC	Canton, O.	254

Location	Wave-length	Call Letters
LOS ANGELES, CAL.	231	KFPR
LOS ANGELES, CAL.	275	KFSG
LOS ANGELES, CAL.	405.2	KHJ
LOS ANGELES, CAL.	238	KMTR
LOS ANGELES, CAL.	208.2	KNRC
LOS ANGELES, CAL.	293.9	KTBI
LOUISVILLE, KY.	399.8	WHAS
LOUISVILLE, KY.	275	WLAP
MACON, GA.	261	WMAZ
MADISON, WIS.	535.4	WHA
MADISON, WIS.	236	WIBA
MANHATTAN, KAN.	218.8	KFVH
MANHATTAN, KAN.	340.7	KSAC
MANSFIELD, CONN.	275	WCAC
MARSHFIELD, WIS.	229	WGBR
MARSHALLTOWN, IA.	248	KFJB
MASON, O.	325.9	WSAI
MEDFORD, MASS.	261	WARC
MEMPHIS, TENN.	278	WGBC
MEMPHIS, TENN.	233	WHBQ
MEMPHIS, TENN.	499.7	WMC
MIAMI, FLA.	263	WQAM
MIAMI BEACH, FLA.	384.4	WMBF
MILWAUKEE, WIS.	275	WHAD
MILWAUKEE, WIS.	261	WKAF
MILWAUKEE, WIS.	246	WSOE
MINNEAPOLIS, MINN.	231	KFDZ
MINNEAPOLIS, MINN.	244	WAMD
MINNEAPOLIS, MINN.	263	WHAT
MINNEAPOLIS, MINN.	278	WHDI
MINNEAPOLIS, MINN.	252	WRHM
MISSOULA, MONT.	244	KUOM
MOBERLY, MO.	242	KFFP
MOBERLY, MO.	242	KFOJ
MONTGOMERY, ALA.	231	WIBZ
MOOSEHEART, ILL.	370.2	WJJD
MT. CLEMENS, MICH.	246	WABX
MT. PROSPECT, ILL.	322.4	WJAZ
MUSCATINE, IA.	256	KTNT
NASHVILLE, TENN.	236	WCBQ
NASHVILLE, TENN.	226	WDAD
NASHVILLE, TENN.	282.8	WSM
NEWARK, N. J.	263	WEPI
NEWARK, N. J.	252	WGCP
NEWARK, N. J.	252	WNJ
NEWARK, N. J.	405.2	WOR
NEW BEDFORD, MASS.	209.7	WIBH
NEW BEDFORD, MASS.	248	WNBH
NEW HAVEN, CONN.	268	WDRC
NEW ORLEANS, LA.	268	WJBO
NEW ORLEANS, LA.	275	WABZ
NEW ORLEANS, LA.	252	WBBS
NEW ORLEANS, LA.	263	WCBE
NEW ORLEANS, LA.	270	WOWL
NEW ORLEANS, LA.	319	WSMB
NEW ORLEANS, LA.	275	WWL
NEW YORK, N. Y.	209.7	WBNY
NEW YORK, N. Y.	491.5	WEAF
NEW YORK, N. Y.	273	WEBJ
NEW YORK, N. Y.	226	WEBL
NEW YORK, N. Y.	226	WEBM
NEW YORK, N. Y.	273	WFBH
NEW YORK, N. Y.	315.6	WGBS
NEW YORK, N. Y.	240	WHAP
NEW YORK, N. Y.	361.2	WHN
NEW YORK, N. Y.	405.2	WJY
NEW YORK, N. Y.	454.3	WJZ
NEW YORK, N. Y.	288.3	WLWL
NEW YORK, N. Y.	526	WNYC
NEW YORK, N. Y.	233	WOKO
NEW YORK, N. Y.	361.2	WQAO
NEW YORK, N. Y.	236	WRMU
NEW YORK, N. Y.	258	WRNY
NEW YORK, N. Y.	263	WSDA
NORFOLK, NEB.	270	WJAG
NORFOLK, VA.	222	WBBW
NORFOLK, VA.	261	WTAR
NORMAN, OKLA.	254	WNAD
NORTH BEND, WASH.	215.7	KFQW
NORTHFIELD, MINN.	336.9	KFMX
NORTHFIELD, MINN.	336.9	WCAL
NORTH PLAINFIELD, N. J.	261	WEAM
OAK, NEB.	268	KFEQ
OAKLAND, CAL.	220	KFUU
OAKLAND, CAL.	256	KFUS
OAKLAND, CAL.	206.8	KFWM
OAKLAND, CAL.	361.2	KGO
OAKLAND, CAL.	250	KLS

Wave Length	Location	Call Letters
254	Greentown, Ind.	WJAK
254	Ithaca, N Y.	WEAI
254	Norman, Okla.	WNAD
254	Osseo, Wis.	WTAQ
254	St. Petersburg, Fla.	WJBB
254	University Place, Neb.	WCAJ
256	Berkley, Cal.	KRE
256	Chattanooga, Tenn.	WDOD
256	Detroit, Mich.	WMBC
256	Escanaba, Mich.	WRAK
256	Grand Rapids, Mich.	WBDC
256	Hanover, N. H.	WDCH
256	Johnstown, Pa.	WHBP
256	Muscatine, Ia.	KTNT
256	Oakland, Cal.	KFUS
256	Portland, Me.	WCSH
258	Richmond, Va.	WRVA
256	Sycamore, Ill.	WJBN
256	Walla Walla, Wash.	KFCF
256	Washington, D. C.	WRHF
256	Wilkes-Barre, Pa.	WBAX
256	Yakima, Wash.	KFIQ
258	Akron, O.	WADC
258	Carterville, Mo.	KFPW
258	Chicago, Ill.	WLTS
258	Chicago, Ill.	WPCC
258	Cincinnati, O.	WAAD
258	Galveston, Tex.	KFUL
258	Lancaster, Pa.	WDBC
258	New York, N. Y.	WRNY
258	Omaha, Neb.	KOCH
258	Omaha, Neb.	WNAL
258	Rochester, N. Y.	WHEC
258	Royal Oak, Mich.	WAGM
261	Bay City, Mich.	WSKC
261	Boston, Mass.	WDBR
261	Boulder, Co.	KFAJ
261	Fargo, N. D.	WDAY
261	Haverford, Pa.	WABQ
261	Kennonwood, La.	KWKH
261	Lambertville, N. J.	WTAZ
261	Macon, Ga.	WMAZ
261	Medford, Mass.	WARC
261	Milwaukee, Wis.	WKAF
261	Norfolk, Va.	WTAR
261	North Plainfield, N. J.	WEAM
261	Ogden, Utah	KFWA
261	Oklahoma City, Okla.	KFJF
261	St. Louis, Mo.	KFQA
261	Salt Lake City, Utah	KFUT
261	Sioux City, Ia.	KFMR
261	State College, Pa.	WPSC
263	Amarillo, Tex.	WDAG
263	Canton, N. Y.	WCAD
263	Fort Worth, Tex.	KFQB
263	Houghton, Mich.	KFMW
263	Houghton, Mich.	WWAO
263	Miami, Fla.	WQAM
263	Minneapolis, Minn.	WHAT
263	Newark, N. J.	WEPI
263	New Orleans, La.	WCBE
263	New York, N. Y.	WSDA
263	Portland, Ore.	KTBR
263	Portland, Ore.	KFJR
263	San Antonia, Tex.	WCAR
263	Savannah, Ga.	WEBZ
263	Shenandoah, Ia.	KFNF
263	Toledo, O.	WABR
263	Yellow Springs, O.	WRAV
266	Chicago, Ill.	WBCN
266	Chicago, Ill.	WENR
266	Clearwater, Fla.	WGHB
266	Dearborn, Mich.	WWI
266	Denver, Col.	KLZ
266	Fall River, Mass.	WTAB
266	Lockport, N. Y.	WMAK
266	Spokane, Wash.	KFIO
266	Spokane, Wash.	KFPY
266	Wilmington, Del.	WHAV
268	Beloit, Wis.	WEBW
268	Cedar Rapids, Ia.	WJAM
268	Charleston, S. C.	WBBY
268	Chicago, Ill.	WSAX
268	El Paso, Tex.	WDAH
268	Gloucester City, N. J.	WRAX
268	Indianapolis, Ind.	WFBM
268	Johnstown, Pa.	WTAC
268	Knoxville, Tenn.	WNOX

Call Letters	Location	Wave-length
WHBD	Bellefontaine O.	222
WHBF	Rock Island, Ill.	222
WHBG	Harrisburg, Pa.	231
WHBH	Culver, Ind.	222
WHBJ	Fort Wayne, Ind.	234
WHBK	Ellsworth, Me.	231
WHBL	Logansport, Ind.	215.7
WHBM	Chicago, Ill.	233
WHBN	St. Petersburg, Fla.	238
WHBP	Johnstown, Pa.	256
WHBQ	Memphis, Tenn.	233
WHBU	Anderson, Ind.	218.8
WHBW	Philadelphia, Pa.	215.7
WHDI	Minneapolis, Minn.	278
WHEC	Rochester, N. Y.	258
WHK	Cleveland, O.	273
WHN	New York, N. Y.	361.2
WHO	Des Moines, Ia.	526
WHT	Deerfield, Ill.	238
WIAD	Philadelphia, Pa.	250
WIAS	Burlington, Ia.	254
WIBA	Madison, Wis.	236
WIBC	St. Petersburg, Fla.	222
WIBG	Elkins Park, Pa.	222
WIBH	New Bedford, Mass.	209.7
WIBI	Flushing, N. Y.	218.8
WIBJ	Chicago, Ill.	215.7
WIBM	Chicago, Ill.	215.7
WIBO	Chicago, Ill.	226
WIBR	Weirton, W. Va.	246
WIBS	Elizabeth, N. J.	202.6
WIBU	Poynette, Wis.	222
WIBW	Logansport, Ind.	220
WIBX	Utica, N. Y.	205.4
WIBZ	Montgomery, Ala.	231
WIL	St. Louis, Mo.	273
WIOD	West Palm Beach, Fla.	248
WIP	Philadelphia, Pa.	508.2
WJAD	Waco, Tex.	352.7
WJAG	Norfolk, Neb.	270
WJAK	Greentown, Ind.	254
WJAM	Cedar Rapids, Ia.	268
WJAR	Providence, R. I.	305.9
WJAS	Pittsburg, Pa.	275
WJAX	Jacksonville, Fla.	336.9
WJAZ	Mount Prospect, Ill.	322.4
WJBA	Joliet, Ill.	206.8
WJBB	St. Petersburg, Fla.	254
WJBC	La Salle, Ill.	234
WJBG	Charlotte, N. C.	224
WJBI	Red Bank, N. J.	218.8
WJBK	Ypsilanti, Mich.	233
WJBL	Decatur, Ill.	270
WJBN	Sycamore, Ill.	256
WJBO	New Orleans, La.	268
WJBP	Buffalo, N. Y.	218.8
WJBQ	Lewisburg, Pa.	211.1
WJJD	Mooseheart, Ill.	370.2
WJR	Pontiac, Mich.	516.9
WJY	New York, N. Y.	405.2
WJZ	New York, N. Y.	454.3
WKAF	Milwaukee, Wis.	261
WKAQ	San Juan, P. R.	340.7
WKAR	East Lansing, Mich.	285.5
WKAV	Laconia, N. H.	224
WKBB	Joliet, Ill.	214.2
WKBE	Webster, Mass.	231
WKBG	Chicago, Ill.	215.7
WKRC	Cincinnati, O.	422.3
WKY	Oklahoma City, Okla.	275
WLAL	Tulsa, Okla.	250
WLAP	Louisville, Ky.	275
WLBL	Stevens Point, Wis.	278
WLIB	Elgin, Ill.	302.8
WLIT	Philadelphia, Pa.	394.5
WLS	Crete, Ill.	344.6
WLSI	Cranston, R. I.	440.9
WLTS	Chicago, Ill.	258
WLW	Harrison, O.	422.3
WLWL	New York, N. Y.	288.3
WMAC	Cazenovia, N. Y.	275
WMAF	Dartmouth, Mass.	440.9
WMAK	Lockport, N. Y.	266
WMAL	Washington, D. C.	212.6
WMAN	Columbus, O.	278
WMAQ	Chicago, Ill.	447.5
WMAY	St. Louis, Mo.	248
WMAZ	Macon, Ga.	261

Location	Wave-length	Call Letters
OAKLAND, CAL.	508.2	KLX
OAKLAND, CAL.	240	KTAB
OAKLAND, CAL.	240	KZM
OAK PARK, ILL.	250	WGES
OGDEN, UTAH	224	KFUR
OGDEN, UTAH	261	KFWA
OIL CITY. PA.	250	WHBA
OKLAHOMA CITY. OKLA.	261	KFJF
OKLAHOMA CITY, OKLA.	214.2	KFXR
OKLAHOMA CITY, OKLA.	275	WKY
OLYMPIA, WASH.	218.8	KFRW
OMAHA, NEB.	248	KFOX
OMAHA, NEB.	258	KOCH
OMAHA, NEB.	278	WAAW
OMAHA, NEB.	258	WNAL
OMAHA, NEB.	526	WOAW
ORONO, ME.	252	WGBX
OSKALOOSA, IA.	240	KFHL
OSSEO, WIS.	254	WTAQ
OWOSSO, MICH.	240	WSMH
OXFORD, MISS.	242	WCBH
OXNARD, CAL.	205.4	KFYF
PARKESBURG, PA.	220	WQAA
PASADENA, CAL.	229	KPPC
PASADENA, CAL.	315.6	KPSN
PATERSON, N. J.	224	WODA
PETOSKEY, MICH.	238	WBBP
PHILADELPHIA, PA.	242	WABY
PHILADELPHIA, PA.	278	WCAU
PHILADELPHIA, PA.	234	WFBD
PHILADELPHIA, PA.	394.5	WFI
PHILADELPHIA, PA.	215.7	WHBW
PHILADELPHIA, PA.	250	WIAD
PHILADELPHIA, PA.	508.2	WIP
PHILADELPHIA, PA.	394.5	WLIT
PHILADELPHIA, PA.	250	WNAT
PHILADELPHIA, PA.	508.2	WOO
PHILADELPHIA, PA.	250	WWAD
PHOENIX, ARIZ.	273	KFAD
PHOENIX, ARIZ.	238	KFCB
PINEVILLE, LA.	238	KFWU
PITTSBURG, PA.	275	KQV
PITTSBURG, PA.	461.3	WCAE
PITTSBURG, PA.	275	WJAS
PLAINFIELD, ILL.	242	WWAE
POMEROY, O.	244	WSAZ
PONTIAC, MICH.	516.9	WJR† WCX
PORT HURON, MICH.	275	WAFD
PORTLAND, ME.	256	WCSH
PORTLAND, ORE.	248	KFEC
PORTLAND, ORE.	248	KFIF
PORTLAND, ORE.	263	KFJR
PORTLAND, ORE.	212.6	KFWV
PORTLAND, ORE.	491.5	KGW
PORTLAND, ORE.	212.6	KQP
PORTLAND, ORE.	263	KTBR
POYNETTE, WIS.	222	WIBU
PROVIDENCE, R. I.	205.4	WCBR
PROVIDENCE, R. I.	209.7	WCWS
PROVIDENCE, R. I.	270	WEAN
PROVIDENCE, R. I.	234	WGBM
PROVIDENCE, R. I.	305.9	WJAR
PULLMAN, WASH.	348.6	KWSC
RALEIGH, N. C.	252	WRCO
RAPID CITY, S. D.	240	WCAT
READING, PA.	238	WRAW
RED BANK, N. J.	218.8	WJBI
RICHMOND HILL, N. Y.	315.6	WAHG
RICHMOND HILL, N. Y.	236	WBOQ
RICHMOND HILL, N. Y.	236	WGMU
RICHMOND HILL, N. Y.	212.6	WWGL
RICHMOND, VA.	229	WBBL
RICHMOND, VA.	256	WRVA
ROANOKE, VA.	229	WDBJ
ROCHESTER, N. Y.	278	WABO
ROCHESTER, N. Y.	278	WHAM
ROCHESTER, N. Y.	258	WHEC
ROCKFORD, ILL.	229	KFLV
ROCK ISLAND, ILL.	222	WHBF
ROSSVILLE, N. Y.	273	WBBR
ROYAL OAK, MICH.	258	WAGM
SACRAMENTO, CAL.	248	KFBK
ST. CLOUD, MINN.	273	WFAM
ST. LOUIS, MO.	261	KFQA
ST. LOUIS, MO.	545.1	KFUO
ST. LOUIS, MO.	240	KFVE
ST. LOUIS, MO.	214.2	KFWF

Wave Length	Location	Call Letters
268	New Haven, Conn.	WDRC
268	New Orleans, La.	WJBO
268	Oak, Neb.	KFEQ
268	San Francisco, Cal.	KFRC
263	Wichita, Kan.	KFH
268	Worcester, Mass.	WTAG
270	Ames, Ia.	WOI
270	Atlanta, Ga.	WDBE
270	Atlanta. Ga.	WGST
270	College Station, Tex.	WTAW
270	Decatur, Ill.	WBAO
270	Decatur, Ill.	WJBL
270	Detroit, Mich.	WGHP
270	Hamilton, O.	WRK
270	Honolulu, Hawaii	KGU
270	Laramie, Wyo.	KFBU
270	New Orleans, La.	WOWL
270	Norfolk, Neb.	WJAG
270	Providence, R. I.	WEAN
270	Stanford University, Cal.	KFGH
273	Anita, Ia.	KFLZ
273	Brookings, S. D.	KFDY
273	Cleveland, O.	WHK
273	Fondulac, Wis.	KFIZ
273	Greeley, Col.	KFKA
273	New York, N. Y.	WFBH
273	New York, N. Y.	WEBJ
273	Phoenix, Ariz.	KFAD
273	Rossville, N. Y.	WBBR
273	St. Cloud, Minn.	WFAM
273	St. Louis, Mo.	WIL
273	St. Louis, Mo.	WSBF
273	Spokane, Wash.	KHQ
273	Tampa, Fla.	WDAE
273	Tarrytown, N. Y.	WRW
273	Urbana, Ill.	WRM
273	West Lafayette, Ind.	WBAA
275	Agricultural College, N.D.	WPAK
275	Atlantic City, N. J.	WHAR
275	Baltimore, Md.	WCAO
275	Batavia, Ill.	WORD
275	Cazenovia, N. Y.	WMAC
275	Charlotte, N. C.	WBT
275	Dayton, O.	WSMK
275	Elgin, Ill.	WCEE
275	Harrisburg, Ia.	WBAK
275	Havre, Mont.	KFBB
275	Jamestown, N. Y.	WOCL
275	Lawrence, Kan.	KFKU
275	Lincoln, Neb.	WFAV
275	Los Angeles, Cal.	KFSG
275	Louisville, Ky.	WLAP
275	Mansfield, Conn.	WCAC
275	Milwaukee. Wis.	WHAD
275	New Orleans, La.	WABZ
275	New Orleans, La.	WWL
275	Oklahoma City, Okla.	WKY
275	Pittsburg, Pa.	KQV
275	Pittsburg, Pa.	WJAS
275	Port Huron, Mich.	WAFD
275	Sioux City, Ia.	WEAU
275	South Bend, Ind.	WSBT
278	Altoona, Pa.	WFBG
278	Boise, Ida.	KFDD
278	Brownsville, Tex.	KWWG
278	Cedar Rapids, Ia.	KWCR
278	Chicago, Ill.	WAAF
278	Columbus, O.	WMAN
278	Council Bluffs, Ia.	KOIL
278	Fulford-by-the-Sea, Fla.	WGBU
278	Grand Forks, N. D.	KFJM
278	Kansas City, Mo.	WOQ
278	Memphis, Tenn.	WGBC
278	Minneapolis, Minn.	WHDI
278	Omaha, Neb.	WAAW
278	Philadelphia, Pa.	WCAU
278	Rochester, N. Y.	WABO
278	Rochester, N. Y.	WHAM
278	Stevens Point, Wis.	WLBL
278	Tuscola, Ill.	WDZ
278	Valparaiso, Ind.	WRBC
278	Vermillion, S. D.	KUSD
280.2	Boston, Mass.	WNAC
282.8	Boise, Ida.	KFAU
282.2	Corvallis, Ore.	KFDJ
282.8	Lawrenceburg, Tenn.	WOAN
282.8	Nashville, Tenn.	WSM
285.5	Berrien Springs, Mich.	WEMC

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†This station is operated under two call signs.

Call Letters	Location	Wave-length
WMBB	Chicago, Ill.	250
WMBC	Detroit, Mich.	256
WMBF	Miami Beach, Fla.	384.4
WMC	Memphis, Tenn.	499.7
WMCA	Hoboken. N. J.	340.7
WNAB	Boston, Mass.	250
WNAC	Boston, Mass.	280.2
WNAD	Norman, Okla.	254
WNAL	Omaha, Neb.	258
WNAT	Philadelphia, Pa.	250
WNAX	Yankton, S. D.	244
WNBH	New Bedford, Mass.	248
WNJ	Newark, N. J.	252
WNOX	Knoxville, Tenn.	268
WNYC	New York, N.Y.	526
WOAI	San Antonia, Tex.	394.5
WOAN	Lawrenceburg, Tenn.	282.8
WOAW	Omaha, Neb.	526
WOAX	Trenton, N. J.	240
WOC	Davenport, Ia.	483.6
WOCL	Jamestown, N. Y.	275
WODA	Paterson, N. J.	224
WOI	Ames, Ia.	270
WOK	Homewood, Ill.	217.3
WOKO	New York, N. Y.	233
WOO	Philadelphia, Pa.	508.2
WOQ	Kansas City, Mo.	278
WOR	Newark, N. J.	405.2
WORD	Batavia, Ill.	275
WOS	Jefferson City, Mo.	440.9
WOWL	New Orleans, La.	270
WOWO	Fort Wayne, Ind.	227
WPAK	Agricultural College, N. D.	275
WPCC	Chicago, Ill.	258
WPG	Atlantic City, N. J.	299.8
WPRC	Harrisburgh, Pa.	215.7
WPSC	State College, Pa.	261
WQAA	Parkesburg, Pa.	220
WQAE	Springfield, Vt.	246
WQAM	Miami, Fla.	263
WQAN	Scranton, Pa.	250
WQAO	New York, N. Y.	361.2
WQJ	Chicago, Ill.	447.5
WRAF	Laporte, Ind.	224
WRAK	Escanaba, Mich.	256
WRAM	Galesburg, Ill.	244
WRAV	Yellow Springs, O.	263
WRAW	Reading, Pa.	238
WRAX	Gloucester City, N. J.	268
WRBC	Valparaiso, Ind.	278
WRC	Washington, D. C.	468.5
WRCO	Raleigh, N. C.	252
WREC	Coldwater, Miss.	254
WREO	Lansing, Mich.	285.5
WRHF	Washington, D. C.	256
WRHM	Minneapolis, Minn.	252
WRK	Hamilton, O.	270
WRM	Urbana, Ill.	273
WRMU	New York, N. Y.	236
WRNY	New York, N. Y.	258
WRR	Dallas, Tex.	246
WRST	Bay Shore, N. Y.	215.7
WRVA	Richmond, Va.	256
WRW	Tarrytown, N. Y.	273
WSAI	Mason, O.	325.9
WSAJ	Grove City. Pa.	229
WSAN	Allentown, Pa.	229
WSAR	Fall River, Mass.	254
WSAX	Chicago, Ill.	268
WSAZ	Pomeroy, O.	244
WSB	Atlanta, Ga.	428.3
WSBC	Chicago, Ill.	209.7
WSBF	St. Louis, Mo.	273
WSBT	South Bend, Ind.	275
WSDA	New York, N. Y.	263
WSKC	Bay City, Mich.	261
WSM	Nashville, Tenn.	282.8
WSMB	New Orleans, La.	319
WSMH	Owosso, Mich.	240
WSMK	Dayton, O.	275
WSOE	Milwaukee, Wis.	246
WSRO	Hamilton, O.	252
WSUI	Iowa City, Ia.	483.6
WTAB	Fall River, Mass.	266
WTAC	Johnstown, Pa.	268
WTAD	Carthage, Ill.	236
WTAG	Worcester, Mass.	268
WTAL	Toledo, O.	252

Location	Wave-length	Call Letters
ST. LOUIS, MO.	233	KMOX
ST. LOUIS, MO.	545.1	KSD
ST. LOUIS, MO.	248	WEW
ST. LOUIS, MO.	273	WIL
ST. LOUIS, MO.	248	WMAY
ST. LOUIS, MO.	273	WSBF
ST. PAUL, MINN.	252	KFOY
ST. PAUL-MINNEAP., MINN.	416.4	WCCO
ST. PETFRSBURG, FLA.	238	WHBN
ST. PETERSBURG, FLA.	222	WIBC
ST. PETERSBURG, FLA.	254	WJBB
SALT LAKE CITY, UTAH	246	KDYL
SALT LAKE CITY, UTAH	236	KFOO
SALT LAKE CITY, UTAH	261	KFUT
SALT LAKE CITY, UTAH	299.8	KSL
SAN ANTONIO, TEX.	263	WCAR
SAN ANTONIO, TEX.	394.5	WOAI
SAN BENITO, TEX.	236	KFLU
SAN DIEGO, CAL.	224	KFBC
SAN DIEGO, CAL.	246	KFVW
SAN FRANCISCO, CAL.	268	KFRC
SAN FRANCISCO, CAL.	234	KGTT
SAN FRANCISCO, CAL.	220	KJBS
SAN FRANCISCO, CAL.	428.3	KPO
SAN FRANCISCO, CAL.	250	KUO
SAN JOSE, CAL.	217.3	KFAF
SAN JOSE, CAL.	231	KQW
SAN JUAN, P. R.	340.7	WKAQ
SAN PEDRO, CAL.	205.4	KFVD
SANTA MARIA, CAL.	209.7	KFXC
SAVANNAH, GA.	263	WEBZ
SCHENECTADY, N. Y.	379.5	WGY
SCRANTON, PA.	240	WGBI
SCRANTON, PA.	250	WQAN
SEATTLE, WASH.	454.3	KFOA
SEATTLE, WASH.	384.4	KJR
SEATTLE, WASH.	305.9	KTCL
SEATTLE, WASH.	454.3	KTW
SEYMOUR, IND.	226	WFBE
SHENANDOAH, IA.	263	KFNF
SHENANDOAH, IA.	252	KMA
SHREVEPORT, LA.	250	KFOX
SIOUX CITY, IA.	261	KFMR
SIOUX CITY, IA.	275	WEAU
SOUTH BEND, IND.	275	WSBT
SOUTH SAN FRANCISCO, CAL.	226	KFWI
SPOKANE, WASH.	266	KFIO
SPOKANE, WASH.	266	KFPY
SPOKANE, WASH.	273	KHQ
SPRINGFIELD, MASS.	333.1	WBZ
SPRINGFIELD, O.	248	WCSO
SPRINGFIELD, VT.	246	WQAE
STANFORD UNIVERSITY, CAL.	270	KFGH
STATE COLLEGE, N. M.	348.6	KOB
STATE COLLEGE, PA.	261	WPSC
STEVENS POINT, WIS.	278	WLBL
STOCKTON, CAL.	248	KWG
STREATOR, ILL.	231	WTAX
SUPERIOR, WIS.	242	WEBC
SYCAMORE, ILL.	256	WJBN
SYRACUSE, N. Y.	252	WFBL
TACOMA, WASH.	250	KMO
TACOMA PARK, MD.	222	WBES
TAMPA, FLA.	273	WDAE
TARRYTOWN, N. Y.	273	WRW
TAUNTON, MASS.	229	WAIT
TOLEDO, O.	263	WABR
TOLEDO, O.	252	WTAL
TRENTON, N. J.	240	WOAX
TRINIDAD, COL.	238	KFBS
TROY, N. Y.	379.5	WHAZ
TULSA, OKLA.	250	WLAL
TUSCOLA, ILL.	278	WDZ
UNIVERSITY PLACE, NEB.	254	WCAJ
UPLAND, CAL.	211.1	KFWC
URBANA, ILL.	273	WRM
UTICA, N. Y.	205.4	WIBX
VALPARAISO, IND.	278	WRBC
VERMILLION. S. D.	278	KUSD
WACO, TEX.	352.7	WJAD
WALLA WALLA, WASH.	256	KFCF
WASHINGTON, D. C.	468.5	WCAP
WASHINGTON, D. C.	212.6	WMAL
WASHINGTON, D. C.	468.5	WRC
WASHINGTON, D. C.	256	WRHF
WEBSTER, MASS.	231	WKBE
WEIRTON, W. VA.	246	WIBR
WELCOME, MINN.	227	KFVN

Wave Length	Location	Call Letters
285.5	East Lansing, Mich.	WKAR
285.5	Lansing, Mich.	WREO
288.3	New York, N. Y.	WLWL
288.3	Hastings, Neb.	KFKX
293.9	Columbus, O.	WAIU
293.9	Columbus, O.	WEAO
293.9	Los Angeles, Cal.	KTBI
296.9	Houston, Tex.	KPRC
299.8	Atlantic City, N. J.	WPG
299.8	Fayetteville, Ark.	KFMQ
299.8	Salt Lake City, Utah	KSL
302.8	Chicago, Ill.	WGN
302.8	Elgin, Ill.	WLIB
305.9	Providence, R. I.	WJAR
305.9	Seattle, Wash.	KTCL
309.1	East Pittsburg, Pa.	KDKA
315.6	Beaumont, Tex.	KFDM
315.6	New York, N. Y.	WGBS
315.6	Pasadena, Cal.	KPSN
315.6	Richmond Hill, N. Y.	WAHG
319	Buffalo, N. Y.	WGR
319	New Orleans, La.	WSMB
322.4	Denver, Col.	KOA
322.4	Mt. Prospect, Ill.	WJAZ
325.9	Mason. O.	WSAI
331.1	Springfield, Mass.	WBZ
336.9	Hollywood, Cal.	KNX
336.9	Jacksonville, Fla.	WJAX
336.9	Northfield, Minn.	KFMX
336.9	Northfield, Minn.	WCAL
340.7	Hoboken, N. J.	WMCA
340.7	Lincoln, Neb.	KFAB
340.7	Manhattan Kan.	KSAC
340.7	San Juan, P. R.	WKAQ
344.6	Crete, Ill.	WLS
344.6	Zion, Ill.	WCBD
348.6	Boston, Mass.	WEEI
348.6	Pullman, Wash.	KWSC
348.6	State College, N. M.	KOB
352.7	Detroit, Mich.	WWJ
352.7	Waco, Tex.	WJAD
361.2	New York, N. Y.	WHN
361.2	New York, N. Y.	WQAO
361.2	Oakland, Cal.	KGO
365.6	Kansas City, Mo.	WDAF
365.6	Kansas City, Mo.	WHB
370.2	Chicago, Ill.	WEBH
370.2	Mooseheart, Ill.	WJJD
374.8	Bristow, Okla.	KVOO
374.8	Hot Springs, Ark.	KTHS
379.5	Schenectady, N. Y.	WGY
379.5	Troy, N. Y.	WHAZ
384.4	Miami Beach, Fla.	WMBF
384.4	Seattle, Wash.	KJR
389.4	Cleveland, O.	WEAR
389.4	Cleveland, O.	WTAM
394.5	Philadelphia, Pa.	WFI
394.5	Philadelphia, Pa.	WLIT
394.5	San Antonia, Tex.	WOAI
399.8	Louisville, Ky.	WHAS
405.2	Los Angeles, Cal.	KHJ
405.2	Newark, N. J.	WOR
405.2	New York, N. Y.	WJY
416.4	St.Paul-Minneapolis, Minn.	WCCO
422.3	Cincinnati, O.	WKRC
422.3	Harrison, O.	WLW
428.3	Atlanta, Ga.	WSB
428.3	San Francisco, Cal.	KPO
440.9	Cranston, R. I.	WDWF† WLSI
440.9	Dartmouth, Mass.	WMAF
440.9	Independence, Mo.	KLDS
440.9	Jefferson City, Mo.	WOS
447.5	Chicago, Ill.	WMAQ
447.5	Chicago, Ill.	WQJ
454.3	New York, N. Y.	WJZ
454.3	Seattle, Wash.	KTW
454.3	Seattle, Wash.	KFOA
461.3	Pittsburg, Pa.	WCAE
468.5	Los Angeles, Cal.	KFI
468.5	Washington, D. C.	WCAP
468.5	Washington, D. C.	WRC
475.9	Dallas, Tex.	WFAA
475.9	Fort Worth, Tex.	WBAP
475.9	Hartford, Conn.	WTIC
483.6	Davenport, Ia.	WOC
483.6	Iowa City, Ia.	WSUI
491.5	New York, N. Y.	WEAF

Call Letters	Location	Wave-length	Location	Wave-length	Call Letters	Wave Length	Location	Call Letters
WTAM	Cleveland, O.	389.4	**WEST LAFAYETTE, IND.**	273	WBAA	**491.5**	Portland, Ore.	KGW
WTAP	Cambridge, Ill.	242	**WEST PALM BEACH, FLA.**	248	WIOD	**499.7**	Columbia, Mo.	KFRU
WTAQ	Osseo, Wis.	254	**WICHITA, KAN.**	231	KFOT	**499.7**	Memphis, Tenn.	WMC
WTAR	Norfolk, Va.	261	**WICHITA, KAN.**	268	KFH	**508.2**	Oakland, Cal.	KLX
WTAW	College Station, Tex.	270	**WILKES-BARRE, PA.**	256	WBAX	**508.2**	Philadelphia, Pa.	WIP
WTAX	Streator, Ill.	231	**WILKES-BARRE. PA.**	231	WBRE	**508.2**	Philadelphia, Pa.	WOO
WTAZ	Lambertville, N. J.	261	**WILMINGTON, DEL.**	266	WHAV	**516.9**	Pontiac, Mich.	WJR† WCX
WTIC	Hartford, Conn.	475.9	**WINTER PARK, FLA.**	240	WDBO			
WWAD	Philadelphia, Pa.	250	**WOOSTER, O.**	206.8	WABW	**526**	Des Moines, Ia.	WHO
WWAE	Plainfield, Ill.	242	**WORCESTER, MASS.**	268	WTAG	**526**	New York, N. Y.	WNYC
WWAO	Houghton, Mich.	263	**YAKIMA, WASH.**	256	KFIQ	**526**	Omaha, Neb.	WOAW
WWGL	Richmond Hill, N. Y.	212.6	**YANKTON, S. D.**	244	WNAX	**535.4**	Chicago, Ill.	KYW
WWI	Dearborn, Mich.	266	**YELLOW SPRINGS, O.**	263	WRAV	**535.4**	Madison, Wis.	WHA
WWJ	Detroit, Mich.	352.7	**YPSILANTI, MICH.**	233	WJBK	**545.1**	St. Louis, Mo.	KFUO
WWL	New Orleans, La.	275	**ZION, ILL.**	344.6	WCBD	**545.1**	St. Louis, Mo.	KSD

†This station is operated under two call signs.

NOTE TO BROADCAST LISTENERS: *The above list of broadcasting stations will be brought up to date and the changes will hereafter be published in each number of* POPULAR RADIO. *Preserve the list given herewith and mark the alterations upon it as they are printed in succeeding issues.*

53 Sources of Interference

In the Receiver Itself or in the Apparatus Connected to it:

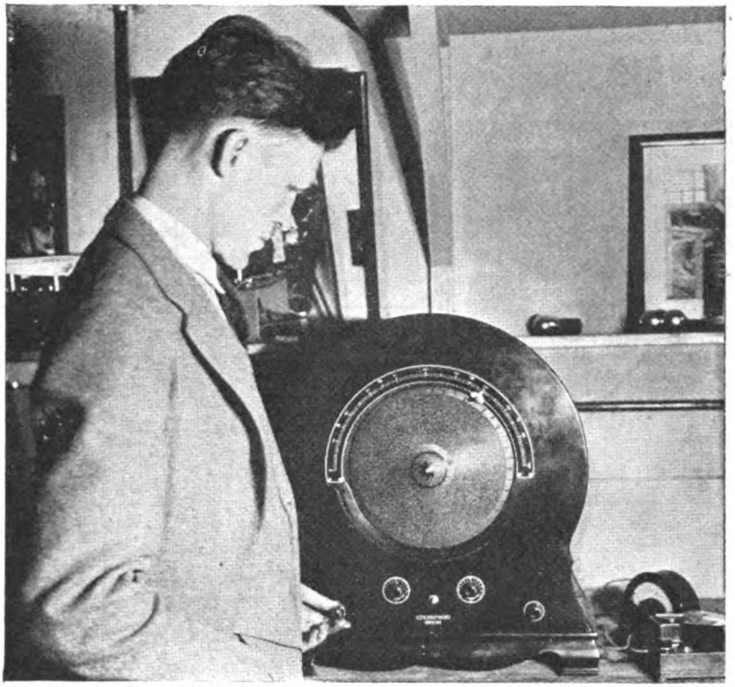
1. An improperly tuned receiver.
2. A loose connection in the receiver or broken wires in the headphone or loudspeaker cord.
3. A defective grid leak.
4. A defective tuning condenser—a momentary shorting of condenser plates.
5. A fixed condenser with defective insulation.
6. Discharged or weak batteries.
7. Loose connections at the batteries.
8. "B" battery eliminators; (in the electrolytic type under certain conditions).
9. A bad socket.
10. A bad tube.

From Apparatus in the Same House with the Receiver—or in a Neighbor's House:

11. Vacuum cleaners.
12. Sewing machine motors or any commutator motor.
13. A violet-ray machine.
14. Ozonators.
15. Door bells and buzzers.
16. Switching of lamps or other electrical devices.
17. Electrical heating pads with thermostat control.
18. Oil burners that use spark ignition; (certain types).
19. Washing machines with split-phase type of motor—if the starting switch is defective.
20. Battery chargers of the vibrating type.
21. Battery chargers of the electrolytic type; (under certain conditions).
22. Elevator controllers and motors of the commutator type.
23. Bad contact in switch, fuse, socket, or other device.
24. Hum caused by having radio receiver or its wiring near lighting wires.

From Outside Sources:

25. Atmospheric static.
26. Regenerative receivers.
27. Sign flashers.
28. Commercial wireless (code) stations.
29. Amateur wireless stations.
30. Induction coils.
31. Electric street cars.
32. Defective rail bonds on street railway systems.
33. Heterodyning of broadcasting stations.
34. Overlapping of broadcasting stations.
35. Telephone ringers.
36. Induction from telephone and telegraph lines.
37. Motion picture machines that use arc lamps.
38. Motors and generators of the commutator type.
39. Electric welding apparatus.
40. X-ray machines.
41. Static machines.
42. Static produced by belts.
43. Electrical manufacturing processes.
44. Induction from high potential circuits.
45. Arcing wire in trees and other grounded objects.
46. Leaking insulators on power circuits.
47. Defective lightning arresters on power circuits.
48. Loose street lamps in sockets.
49. Bad contacts in switches.
50. Lightning arresters.
51. Smoke or dust precipitators.
52. Defective transformers.
53. Defective street light rectifiers.



From a photograph made for POPULAR RADIO

THE THOMPSON MINUET UNDER TEST IN THE LABORATORY

FIGURE 1: *The receiver was also put into operation at specially chosen points in and near New York City in order to reproduce actual operating conditions as far as possible.*

HOW TO GET THE MOST OUT OF

YOUR READY-MADE RECEIVER

No. 10: THE THOMPSON MINUET RECEIVER MODEL R-81

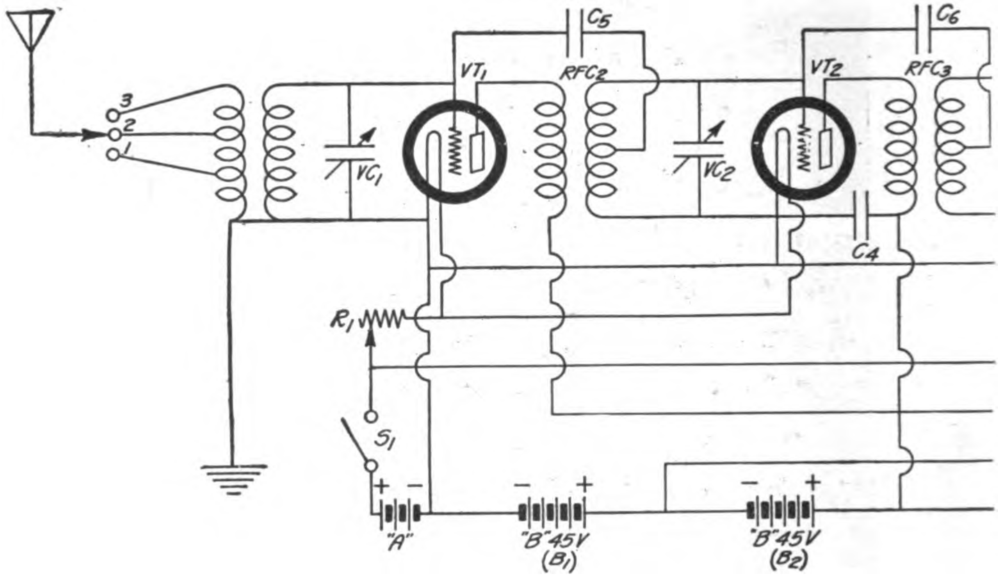
This series of articles explains the theory, operation, equipment and care of standard receiving sets

This series does not indorse the product of any manufacturer nor make comparisons between receivers. The sets already described include: No. 1, the Eagle Neutrodyne; No. 2, the Radiola Superheterodyne; No. 3, the Melco Supreme Receiver; No. 4, the Crosley Trirdyn; No. 5, the De Forest Reflex; No. 6, the Atwater Kent; No. 7, the Grebe Synchrophase Receiver; No. 8, the Freed-Eisemann Receiver; No. 9, the Garod Neutrodyne Type V Receiver.

By S. GORDON TAYLOR

EXPLANATION OF SYMBOLS IN FIGURE 1—

RFC1—Antenna coupling coil;
RFC2 and RFC3—Radio-frequency coupler coils;
VC1, VC2 and VC3—Variable condensers;
VT1, VT2, VT3 and VT4—UX-199 type vacuum tubes;
VT5—UX-120 type amplifier vacuum tube;
AFT1 and AFT2—Audio-frequency amplifying transformers;
R1—Filament rheostat controlling VT1 and VT2;
R2—Filament rheostat controlling VT3, VT4 and VT5;
R3—Grid-leak resistance;
C1, C2, C3 and C4—Fixed condensers;
C5 and C6—Neutralizing condensers;
S1—Battery switch.



THE WIRING DIAGRAM OF THE RECEIVER

Figure 2: *This schematic drawing together with the text should give the novice a general understanding of how the receiver works. The lettering used is identical with that employed in the other illustrations and in the list of parts.*

THIS five-tube receiver is of the tuned-radio-frequency type and employs the neutrodyne method of preventing oscillation in the radio-frequency amplifier. The theory of neutralization used in this type of receiver has already been described in detail in previous articles of this series.*

Construction of the Receiver

This receiver, when it is put into operation, is entirely self-contained. The loudspeaker, tuning control units and the receiver proper as shown in Figures 3, 4 and 5 are all mounted on the battery box and sub-panels while space is provided within the cabinet for all batteries, "A," "B" and "C." All the connecting wires are therefore concealed within the cabinet with the exception of those which lead to the antenna and ground.

Access to the battery compartment and the rear connection block is gained from the rear of the receiver, by the removal of the grill. This is accomplished by turning the knob at the top and pulling the grill out and up.

The variable tuning condensers are mounted on a metal subpanel and are mechanically coupled together by means of wires and pulleys so that they are operated from a single major tuning control at the front. In this way the three tuned circuits are controlled by a single tuning knob which swings in a calibrated arc around the circumference of the loudspeaker cone.

It is impossible, however, in this type of receiver to tune three circuits with a single control and have each one tuned to absolute accuracy. The slight variation involved is not noticeable to any extent in the case of reception from local broadcasting stations but it does become noticeable when an effort is made to bring in distant stations where extremely fine tuning is necessary.

To take care of this variation the manufacturer of this receiver has provided "compensator" controls on the front of the receiver. By means of these controls the slight readjustment of the

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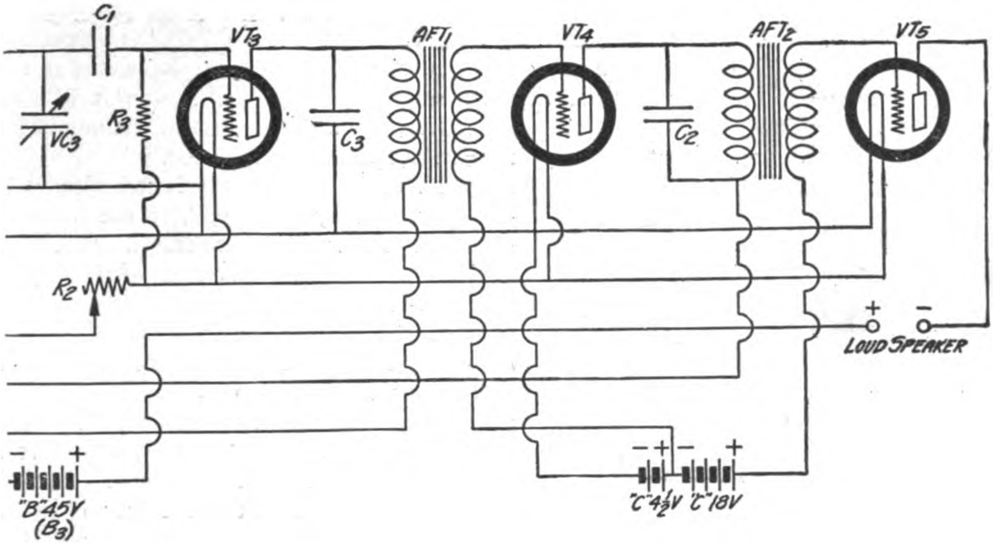
* Those who wish to familiarize themselves with this theory are referred to the articles of this series which appeared in Popular Radio for December, 1924, and August, 1925.



settings of VC1 and VC3 may be made. Thus these two circuits may be brought into exact resonance with the other circuit. The result of this arrangement is a single-control receiver for local reception but with the added refinement of compensator adjustments for sharp tuning.

There are also two knobs on the panel which control the battery current supply to the tube filaments. The one at the right is used to adjust the current to the detector and audio amplifier tubes. When this is once set for maximum results it need not be varied except that it should be advanced somewhat as the voltage of the "A" battery drops through age. The filament knob at the left serves to control the volume of sound by varying the amount of current flow through the filaments of the radio-frequency amplifier tubes. By the use of this control any desired degree of volume may be obtained.

How the Receiver Works

When radio signals are intercepted by the antenna there is a flow of radio-frequency current through the coil which is connected in the antenna-ground circuit, i. e., the primary of RFC1. By means of electromagnetic induction this energy is transferred to the secondary of the antenna coupler RFC1.

The amount of energy transferred in this manner depends upon the ratio of turns in these two coils and the degree of coupling between them. If the energy transfer is too great the tuning, which is controlled by the condenser VC1 shunted across the secondary coil, will be broad when a large antenna is used. This condition may permit two broadcasting stations on different wavelengths to be heard at the same time.

To eliminate this possibility the antenna coil in this receiver is provided with three taps, marked 1, 2 and 3 in Figure 2. If a short antenna is used with the receiver the connection to the tapped part of this coil is made to binding post number 3, which provides the maximum energy transfer to the secondary coil. In other words, a small antenna picks up comparatively little energy from the ether and all of this energy may be used to advantage.

A larger antenna, however, may pick up too much energy. Therefore it should be connected to binding post 1 or 2 which provides fewer turns of the antenna coil in the circuit with the result that the coupling between the two coils is "loose" and there is a comparatively smaller transfer of energy.

Let us assume, for the purpose of illustration, that the energy of the incoming signal has been successfully transferred to the secondary coil of RFC1. It is then necessary to tune this circuit by means of VC1. This must be done because this circuit will accept only energy of the same frequency, or wavelength, as that to which the circuit is tuned. If the secondary is tuned to 300 meters, for instance, the resistance that this circuit offers against the flow of energy is low if the received energy has a frequency of 1,000,000 cycles a second, corresponding to a 300 meter wavelength. The resistance is high to other frequencies, however.

It may be considered then that this tuned secondary circuit accepts signals of the same wavelength to which it is tuned and rejects all others. It follows, of course, that by varying the adjustment of VC1 this circuit may be made an "acceptor" of signals of any wavelength within the range of the circuit (in this receiver the range is approximately 200 to 600 meters), while at the same time serving as a "rejector" of all signals of wavelengths higher or lower than that to which the circuit is tuned.

The secondary of RFC1 is connected to the grid and filament of VT1, as shown in the diagram, Figure 2. Thus the energy put into this coil from the antenna coil is impressed across the grid and filament of the vacuum tube.

Through the amplifying action of the tube the energy taken out of the amplifier tube will be greater than that put into it. The added electrical energy is supplied by the high voltage "B" battery and is taken out across the plate and filament of the tube.

When an impulse of energy is impressed on the grid of the tube, this element acts as a throttle, allowing a corresponding impulse of electrical energy to be drawn from the "B" battery through the plate circuit of the tube. Thus an energy flow is set up in the primary of RFC2 because this coil is connected between the "B" battery and the plate of the tube.

It is evident then that the signal energy which was intercepted by the antenna circuit and transferred to the secondary circuit of RFC1 will be duplicated in the primary circuit of RFC2 but it will, of course, be larger because of the amplification properties of the tube.

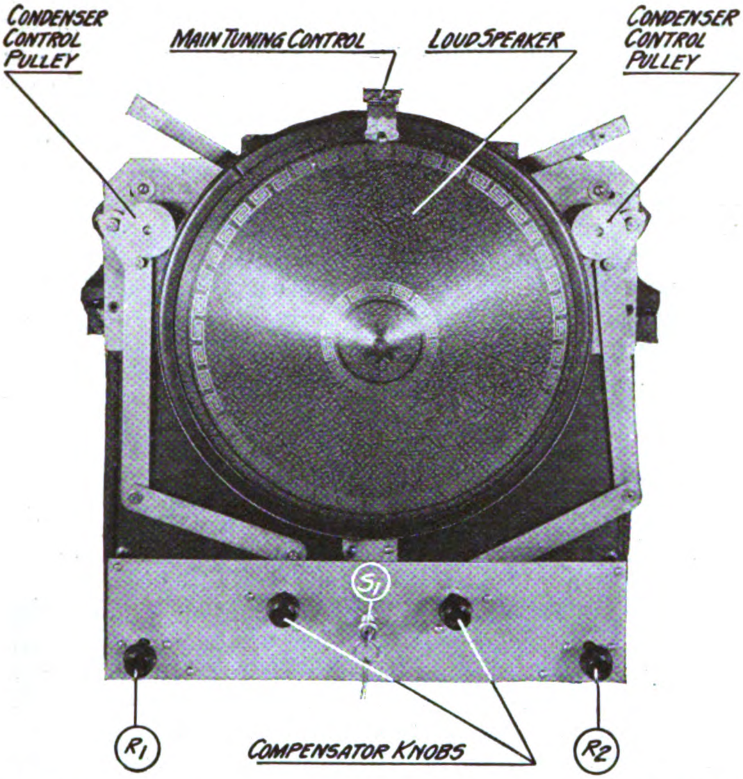
This increased energy is transferred to the secondary of RFC2, if the latter is tuned to the same wavelength. It is then impressed on the grid circuit of the second radio-frequency amplifier tube where further amplification is provided. Thus extremely weak signals intercepted by the antenna are built up so that by the time they are impressed upon the grid of the detector tube, through RFC3, they have a respectable amount of strength. This of course means that the receiver is much more sensitive to weak signals from distant stations than would be the case if a radio-frequency amplifier were not used.

Up to this point all the energy has remained in the form of radio-frequency currents. Radio-frequency energy, however, cannot be made audible by inserting a loudspeaker or headphone in the circuit. It is first necessary to change the form of the current to so-called "audio-frequency." In other words the radio-frequency must be reduced to one within the range of the human ear. This is accomplished by means of the detector tube which has what might be called a semi-rectifying action. The result is that the output of the detector tube practically amounts to a direct current which fluctuates according to the vibration or frequency of the voice or music which is being received.

If headphones were connected in the plate circuit of the detector tube in place of the primary coil of AFT1, these vibrations or frequencies would become audible reproductions of the sounds which were originally broadcast.

In order to make the use of a loudspeaker possible, however, it is necessary to build up the strength of these audio-frequency currents. This is accomplished by the use of two stages of audio-frequency amplification.

The process is the same as that of the radio-frequency amplifier except that th



A FRONT VIEW OF THE RECEIVER, WITH THE CABINET REMOVED

FIGURE 3: *The pulleys which control the two condensers VC1 and VC3 are shown in this picture. The single control at the top also operates the third condenser, VC2. The receiver is completely assembled and wired before it is placed in the cabinet.*

coupling coils (audio-frequency transformers) are of a different type which requires no tuning because they pass nearly all audio-frequency currents with equal facility.

Antenna and Ground

As has been stated, there is a definite limit to the amount of signal energy that can be effectively transferred from the antenna circuit to the receiver. If there is too great an energy transfer the tuning becomes broader, with the result that two stations broadcasting on different wavelengths may be heard at one time. To a certain extent the three connections provided on the antenna coupling coil may be used to adjust the signal strength to suitable proportions. However there are other conditions that should be considered.

If the receiver is located close to powerful broadcasting stations the antenna will pick up a great deal of energy—perhaps so much that even with the antenna connected to the first tap on the antenna coil the energy transfer will be too great unless a small antenna is used. On the other hand, if the nearest broadcasting station is 50 or 100 miles distant it may be possible to use a much larger antenna, even when it is connected to taps 2 or 3 on the antenna coil. Because of the greater distance the signals have to travel, in this latter case, they are naturally comparatively weak when they reach the receiving antenna and therefore the signal energy impressed on the grid circuit of the first tube will be sharp in tuning.

The logical conclusion is that a small antenna should be used if the receiver is to be located within a few miles of a powerful broadcasting station. When there are no nearby stations the antenna may be much larger.

Actually these conclusions are borne out by facts, with the result that an antenna between 60 and 75 feet in length is recommended where there are high power broadcasting stations within a distance of about 30 miles from the receiver. Where the nearest stations are at a greater distance than this a larger antenna may be used—anywhere from 100 to 150 feet in length—depending on the distance.

Previous articles of this series have gone into detail regarding the installation of antennas and ground connections. It does not seem necessary to go over this ground again, especially since the instruction booklet which is furnished with this receiver by the manufacturer covers this subject with great thoroughness. It should suffice to offer an illustration of an ideal antenna arrangement, Figure 6, with the suggestion that it be followed as closely as conditions may permit.

The Vacuum Tubes to Use

This receiver is designed to operate with dry-cell tubes exclusively. As indicated in the list of symbols at the head of this article, UX-199 type tubes are used for the radio-frequency amplifier, detector and first audio amplifier tubes. For the second audio amplifier tube a UX-120 type of tube is used.

If desired, the UX-199 type may be used in all five sockets but the increased volume with the use of a UX-120 tube in the last audio stage is so great as to make the substitution of a UX-199 tube impractical. Therefore the only combination to be discussed here will be that which uses a UX-120 as indicated above.

What Batteries to Use

Dry-cell batteries alone are used to operate this receiver. This includes the "A" battery, which supplies the filament lighting current; the "B" battery, which supplies the high voltage to the tube plate circuits, and the "C" battery, which supplies the proper grid-bias to provide the maximum volume and tone quality in the audio-frequency amplifier.

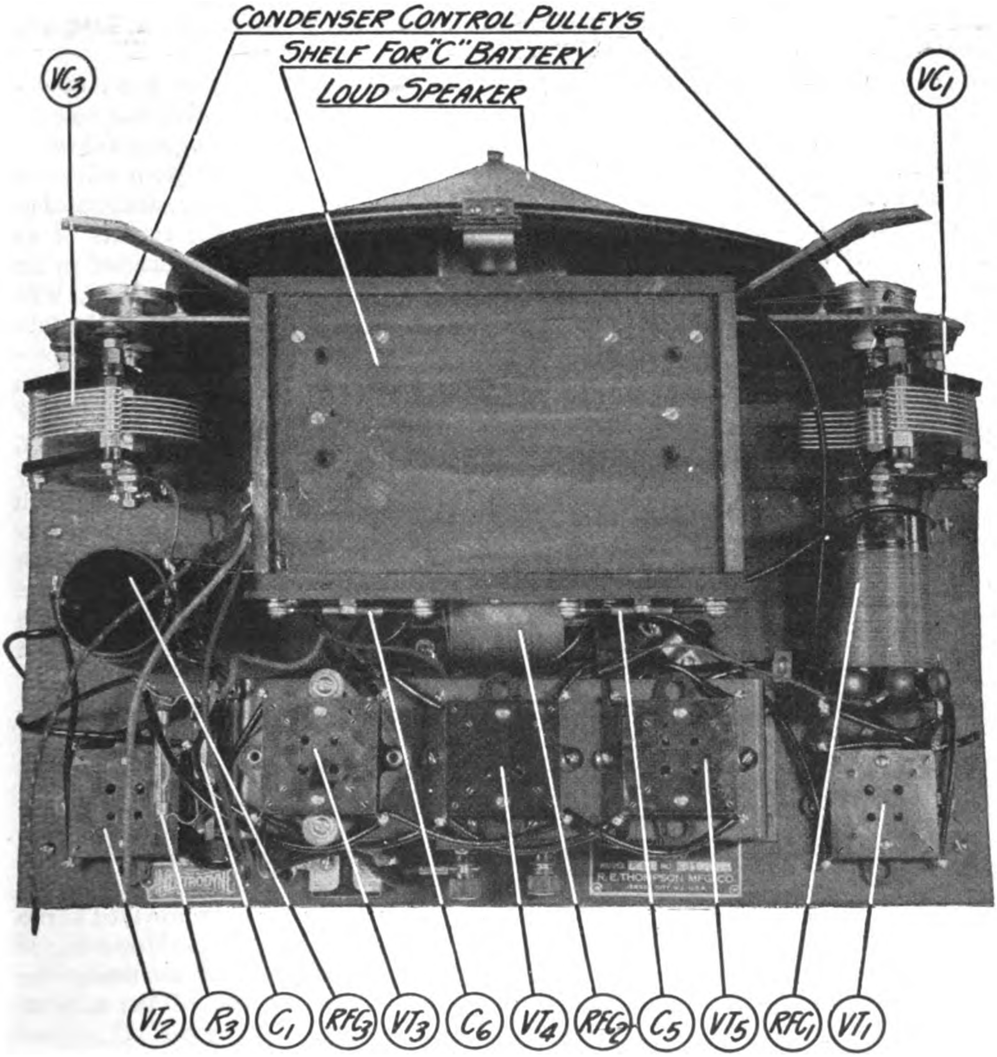
The "A" battery is made up by connecting six ordinary dry cells as shown in Figure 7. By connecting batteries in series their total current is equal to that of only one battery, but their total voltage is equal to the sum of their individual voltages. Therefore, since dry cells are rated at 1½ volts each two connected in series would provide a 3 volt supply.

The UX-199 type of tube operates on three volts but it is necessary to use three dry cells in series to operate these tubes. This is because the voltage of the batteries drops slightly after they have been in use a short while so that two of them in series would not supply an adequate voltage for any length of time. Therefore three dry cells are connected in series to provide suitable voltage, even after their initial voltage has dropped somewhat.

When dry cells are connected in multiple (parallel) their total voltage remains the same as that of a single battery but their current (life) is greatly increased. In some cases, where the current drain is fairly large two batteries connected in multiple will have considerably more than twice the life of a single battery. In such cases it is of course more practical to use two batteries, thus connected, than one.

For lighting the filaments of this receiver, it is therefore recommended that both of these methods of connection be used. This arrangement is shown in Figure 7. The six dry cells are divided into two groups of three each. The three batteries in each set are connected in series, providing a total voltage of 4½ for each set. The two sets are then connected in multiple making the total output voltage 4½ but more than doubling the current life.

In selecting dry cells for use in lighting the filaments of this receiver it is recommended that preference be given to batteries which are made expressly for radio use. The ordinary batteries commonly



A TOP VIEW OF THE RECEIVER

Figure 4: *The greater part of the assembly of the set, as shown here, is mounted on the top of the battery box. VC2 is hidden by the "C" battery shelf.*

used for operating doorbells will not function as satisfactorily as radio dry cells which are so designed as to provide maximum efficiency when subjected to current drains such as those required for operation of vacuum tubes.

The life of a set of six standard radio dry cells, connected to the Thompson receiver, as shown in Figure 7, should approximate 80 to 100 hours of use. This means that if the receiver is used an average of two hours per day, one set of these batteries should last about a month and a half.

A small pocket voltmeter may be used to test the batteries from time to time, to determine their condition. A new battery should register 1½ volts when the voltmeter is connected across its terminals.

As the batteries become worn their voltage drops until they do not provide ample voltage to operate the receiver. When the voltage drops to .9 volt per cell the batteries should be replaced with new. It is a good idea to purchase a new set of batteries when the voltage of the old has dropped to 1 or 1.1 so that the new ones will be on hand when the time comes for their installation.

For the high voltage supply it is possible to use "B" batteries of either the dry or storage type, or one of the devices now on the market which make it possible to obtain the proper voltage supply direct from the house lighting lines. The source most commonly used, of course, is the dry-cell "B" battery. This consists of a number of small dry cells, similar to flash light cells, which are assembled into sealed blocks containing either 15 or 30 cells each, representing total voltages of 22½ and 45 respectively.

Like the dry cells used for lighting the filaments, these batteries must be replaced with new ones when they become worn out. Their condition may be tested with a small voltmeter, as in the case of the dry cell "A" batteries, but in this case the voltmeter should be capable of reading up to 50 volts. The most practical arrangement is to purchase a voltmeter with a double scale; one with a maximum of two or three volts, for use in measuring the voltage of the "A" batteries and the other with a maximum of 50 for measuring the voltage of the individual blocks of the "B" battery. "B" batteries should be replaced when the voltage of a single 45 volt block drops to 34, or a 22½ volt block drops to 17.

The approximate life of a set of dry cell "B" batteries used with this receiver is shown in the tabulation given below.

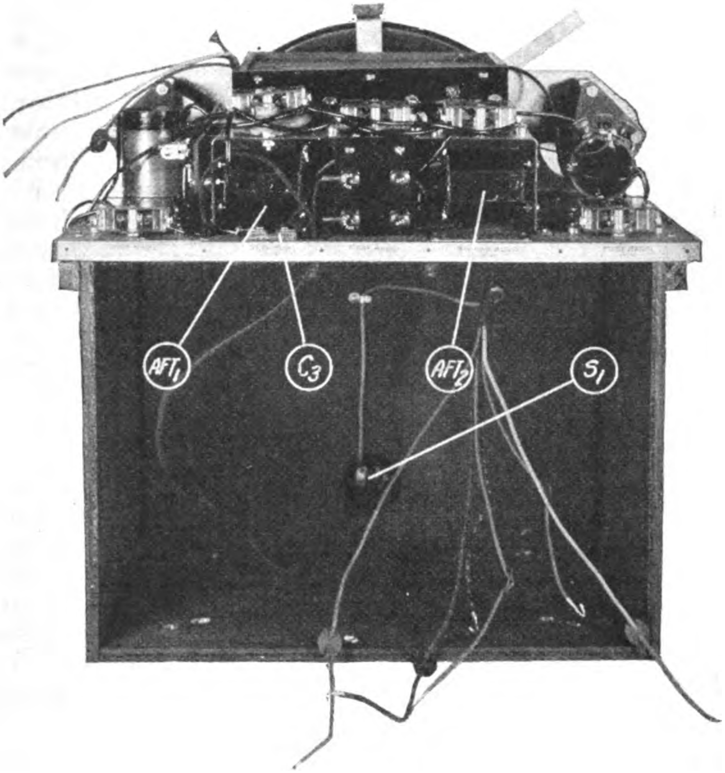
Study of the circuit diagram will show that the first 45 volt battery, designated as "B1" is connected in the circuits of all five tubes, while "B2" is connected in the circuits of only four—VT1, VT2, VT4 and VT5. The current drain of the tube VT3 is so slight as to be of little importance, so it may be considered that the current drain on batteries "B1" and "B2" is approximately equal. "B3," however, is connected in the circuit of VT5 only and is therefore subjected to a much lighter drain than are the other two batteries. It is therefore advisable to switch the batteries around about once a month. Thus, at the end of three months, each battery will have served one month in each of the three positions in the circuit and each will therefore have been subjected to the same drain. If this suggestion is not followed, it will be found that the first two batteries will run down much faster than the third.

Some difficulty will be found in using the storage type of "B" batteries with this receiver because the space provided in the cabinet is not sufficient. However, if there is no objection to mounting the storage batteries outside of the cabinet,

TABLE OF ESTIMATED "B" BATTERY LIFE WITH THE THOMPSON RECEIVERS

Amount of use daily	"B1"	"B2"	"B3"	ALL, IF INTERCHANGED MONTHLY
2 hours	148 days	148 days	388 days	190 days
3 hours	91 days	91 days	288 days	124 days
4 hours	61 days	61 days	228 days	86 days

This approximation of the life of the "B" batteries used with the Thompson receiver is calculated from the actual current drain figures divided into the known ampere hour capacity of standard makes of "B" batteries. It will be noted that if the batteries are not changed around monthly, as suggested in the text, "B1" and "B2" will run down almost three times as rapidly as "B3." By interchanging the batteries monthly, however, the life of all will be approximately equal and it will be a more simple matter to keep the battery voltage checked up.



A REAR VIEW OF THE SET WITHOUT ITS CABINET

FIGURE 5: *The space provided for the batteries is here shown. When the cabinet is in place the batteries may be reached by removing the grill at the rear. The battery arrangement is given in Figure 7.*

their use will be found entirely practical.

The first cost of such batteries is higher than that of the dry cell type. However, storage "B" batteries may be recharged when they run down and will function for years with only an occasional charging. A charger which makes it possible to recharge storage batteries from the electric light line may be purchased for a few dollars, and will enable the owner to charge his batteries at home.

If it is desired to use a "B battery eliminator" one should keep in mind the dimensions of the battery cabinet in the receiver and it is by all means advisable to require a demonstration of the device in conjunction with this particular receiver before the purchase is made. This is especially important because many of the devices which furnish the high voltage plate supply direct from the electric light lines will not function satisfactorily unless several feet away from the receiver.

A 22½-volt "B" battery serves as the "C" battery for this receiver. Heretofore receivers required only about 4½ volts of "C" battery but with the advent of the new power tubes, such as the UX-120, higher "C" battery voltages are required. This is fortunate because otherwise the current drain on the "B" batteries where the voltage is over 100 would be excessive.

The "C" battery serves not only to cut down the current drain on the "B" batteries, but also to improve the tone quality of reproduction.

The "C" battery is subjected to practically no current drain and for that reason its life in the receiver is approximately equal to its shelf life, which is the term used to designate the life of a battery which is not used but which gradually deteriorates and loses strength because of age.

The estimated life of the "C" battery is in excess of 18 months. When its voltage has dropped to 17 it should be replaced.

The Operation of the Receiver

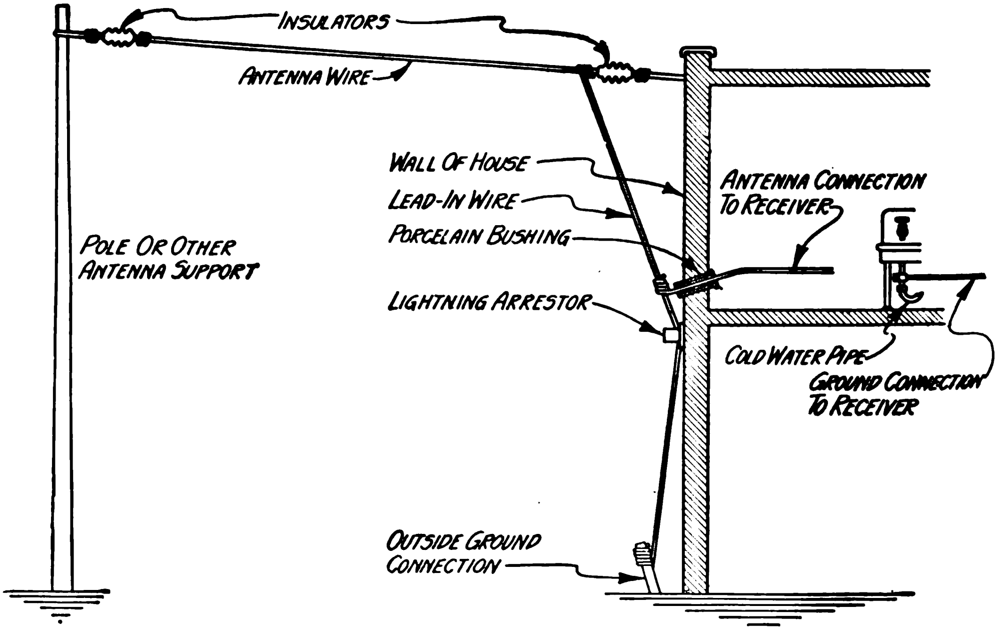
After the batteries, antenna and ground have been connected to the receiver, as shown in Figure 7, it is a simple matter to put it in operation. The five vacuum tubes should be inserted in their sockets, making sure that the UX-120 type tube is placed in the socket marked VT5 in Figure 4. It is also advisable at first, to connect the wire running to the antenna coupler coil to the middle one of the three binding posts mounted on the rear end of this coil.

The filaments of the vacuum tubes are lighted next by inserting the key in the battery switch S1 and turning a quarter turn to either side. The rheostat knobs R1 and R2 are then each turned half way on. At this setting their pointers will point directly upward. With these two operations accomplished, the filaments of the five tubes should glow dimly, and the receiver is in readiness for reception.

The two compensating knobs should then be set at zero and the main tuning control moved slowly over its scale until a broadcast station is heard. The main control may be left at the setting where the signal is loudest.

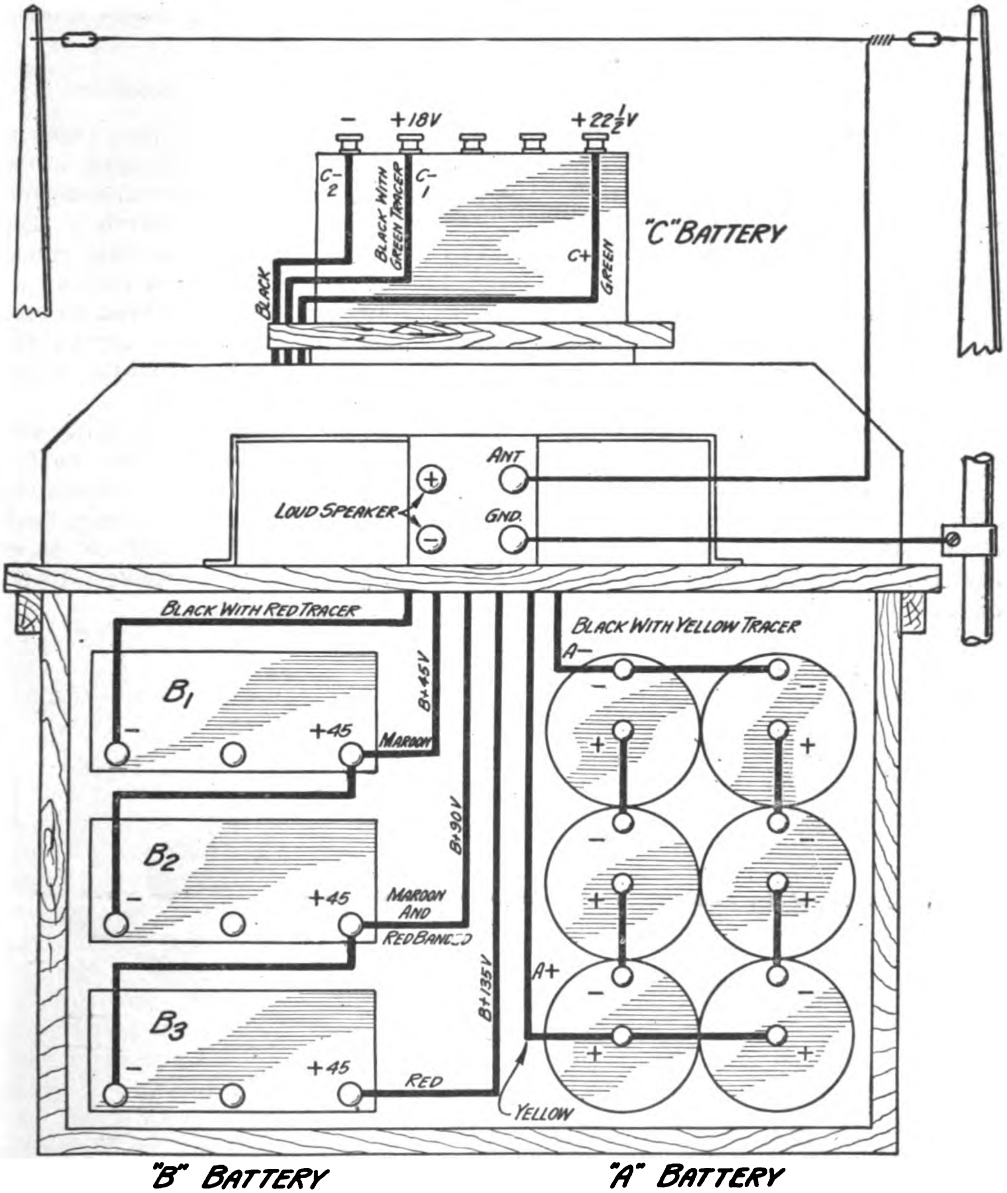
The compensating knobs should then be adjusted in an effort to make the signal still louder. When this has been done the receiver is tuned to exact resonance with the broadcasting station.

At this point the two knobs R1 and R2 should be readjusted. As they are turned to the right they allow greater


INSULATORS
ANTENNA WIRE
WALL OF HOUSE
LEAD-IN WIRE
PORCELAIN BUSHING
LIGHTNING ARRESTOR
POLE OR OTHER ANTENNA SUPPORT
ANTENNA CONNECTION TO RECEIVER
COLD WATER PIPE
GROUND CONNECTION TO RECEIVER
OUTSIDE GROUND CONNECTION

AN EXCELLENT ANTENNA ARRANGEMENT

FIGURE 6: *The design of the antenna is necessarily governed, in most cases, by the roof or yard space available. However, many of the ideas suggested by this illustration may be used to advantage in any antenna installation. The best length for the antenna will depend in each case on the interference conditions.*



THE CONNECTION CHART

FIGURE 7: *This diagram gives the wiring of the batteries, antenna, ground and loud-speaker. The arrangement of the "A," "B" and "C" batteries is also shown.*

current to flow to the filaments of the tubes. With this increased current there will be an increase in volume of received signals up to a certain point. Above this point increasing current will not increase signal strength but will shorten the life of the tubes.

The proper setting of the knobs R1 and R2, therefore, is the lowest one which will provide maximum volume of signals. If maximum volume is not needed, in the case of reception from local stations, it can be cut down to any desired degree by turning the knob R1 backward (left).

When the compensator knobs are set for maximum effectiveness for one broadcasting station they will need little attention unless the wire running to the antenna coupling coil is changed to another terminal. In that case a new setting for them will be necessary. This new setting, however, will hold good for all stations so long as the connection to the antenna coil is not changed.

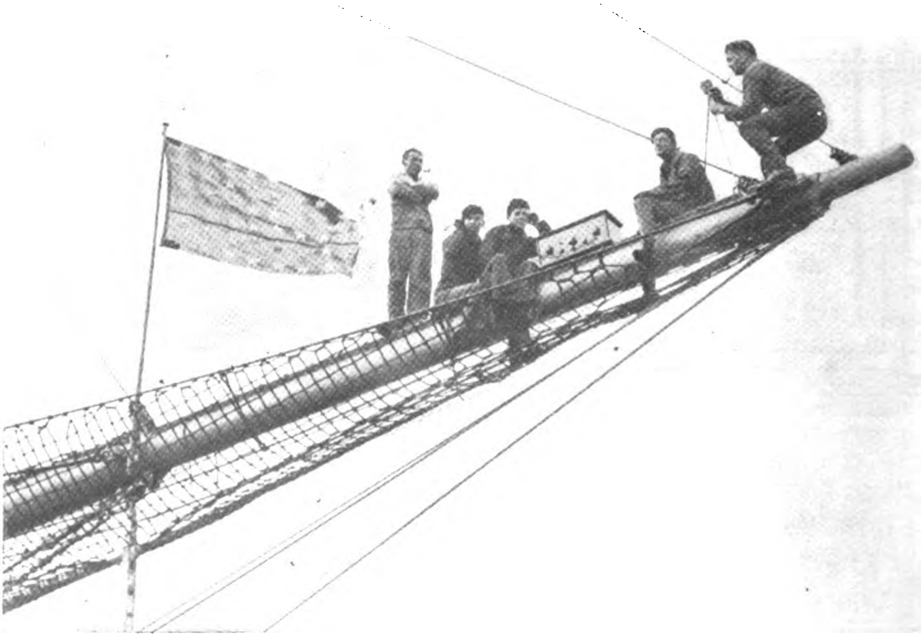
After practicing tuning for a short time, it is well to try changing the connection to the antenna coil from one terminal to another until all three have been tried. Then leave the connection on the terminal which provides the greatest signal strength but which still retains ample selectivity to make possible the reception of any station without interference from another. After the best connection has once been found there is no necessity for again changing it unless a change is made in the antenna.

How to Chart the Receiver

When a station has once been tuned in it can always be brought in again at the same setting of the main tuning control (and the compensating controls). For this reason a notation of the dial setting should be made for each new station.

Thereafter when it is desired to tune in a certain station it is necessary only to refer to these notations to find the proper setting for the tuning control.

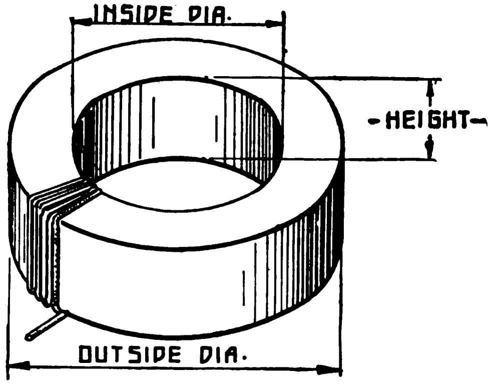
These notations may be made in tabular form and new stations added as they are tuned in. If desired, the stations can later be arranged on a new chart, listed in alphabetical order or in any other arrangement which is convenient to the operator of the receiver.



Kadel & Herbert

"LIFE ON THE ETHER WAVE"

The best point of radio reception on board a vessel is the bowsprit—if the cadets of the New York State schoolship NEWPORT *are to be believed. Radio fans of an experimental turn of mind may care to check up on this conclusion—and on the other hand, they may not!*



THE TYPE OF COIL TO BE MEASURED

FIGURE 1: *The toroid shape of winding, shown in the diagram above, that consists of a circular winding of square cross section may be easily calculated for inductance as explained in the following article.*

A MEASUREMENT CHART

FOR SIMPLE CALCULATION OF INDUCTANCE OF TOROID COILS

ARTICLE No. 14

By RAOUL J. HOFFMAN, A.M.E.

THE trend of development in recent coil design has been somewhat toward the confinement of the magnetic field within the coil in order to eliminate radiation, inductive coupling between stages, and a freedom from outside interference.

The ordinary coil, the solenoid, as used today, has a larger external field which is the main cause of picking up outside energy from nearby stations.

A coil wound around a ring has a completely self-contained magnetic field, and is called a toroidal coil, also known under the popular name as the "doughnut coil."

The simplest form for winding a toroidal coil is a ring with a rectangular cross-section, for which the inductance follows the equation:

$$L = .0117\ n^2h \log 10\ O.D./I.D.$$

wherein L denotes the inductance in microhenrys, n the total number of turns, h the thickness or height of the coil, O.D. the outside diameter and I.D. the inside diameter; all dimensions in inches.

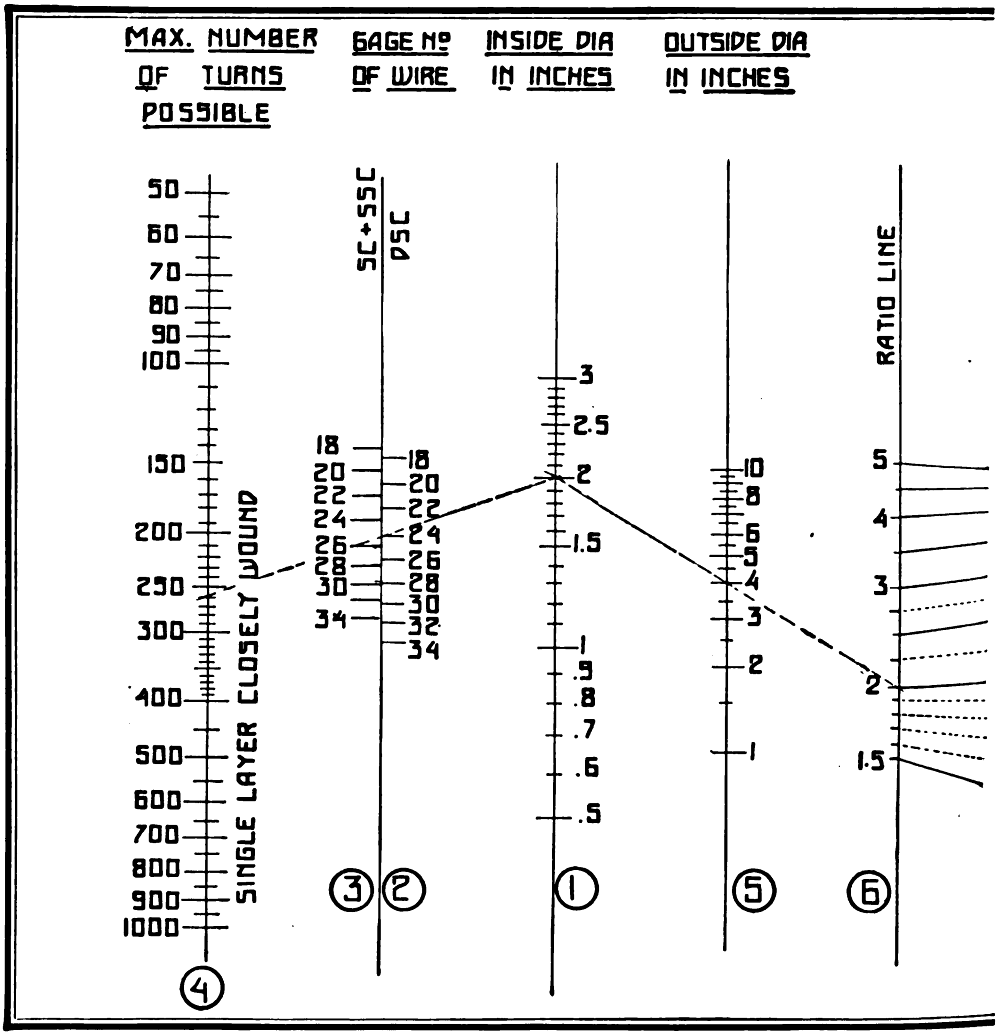
For ready calculations the above formula is represented by a chart as shown in Figure 2.

Figure 1 shows the general design to be calculated.

Using a certain size of wire to be wound on a single layer on a given inside diameter there is a maximum number of turns possible.

Looking at the chart in Figure 1, we find on scale No. 1 the inside diameter of the coil, on scale No. 2 the double silk covered wire and on scale No. 3 the single silk over single cotton covered wire; by connecting scale No. 1 with scale No. 2 or scale No. 3 we find the line intersecting scale No. 4 at the maximum number of turns possible.

Example: To find the inductance of a toroidal coil having a height of 1.5 inches an outside diameter of 4 inches and an inside diameter of 2 inches using



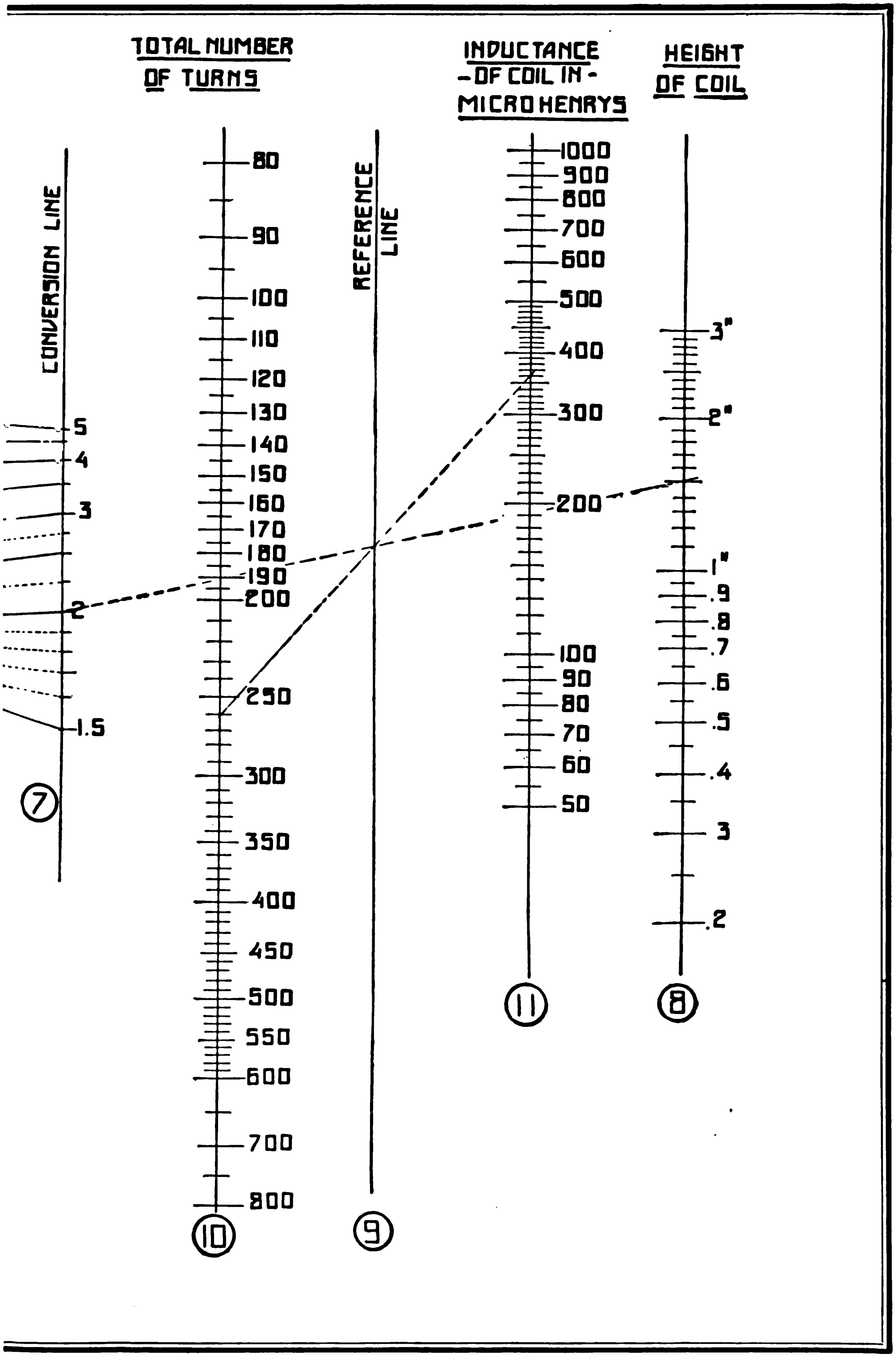
THE CHART THAT HELPS YOU TO DESIGN THE TOROID COIL

FIGURE 2: *By means of this simplified chart the amateur experimenter may design his toroid coils to any inductance value that he desires to use in his receiving set. The chart takes into consideration the number of turns of wire necessary, kind of wire, the inside and outside diameters of the toroid and the height of the windings for obtaining a coil of a certain specified inductance value.*

No. 24 D.S.C. wire. Connect 2 on scale No. 1 with 24 on scale No. 2 you will find the line intersecting 260 on scale No. 4 which is the maximum number of turns possible for a single layer.

Then connecting 2 on scale No. 1 with 4 on scale No. 5, you will find the line intersecting 2 on scale No. 6 which gives the ratio of the outside and inside diameter; taking the same ratio number on the conversion line No. 7 and connecting it with 1.5 on scale No. 8, then connecting the intersection point on the reference line No. 9 with 260 on scale No. 10 you will find the inductance on scale No. 11 to be 360 microhenrys.

¶ *The next* MEASUREMENT CHART *of this series will enable the experimenter to figure out the inductance of the circular section toroid coil.*


TOTAL NUMBER OF TURNS
INDUCTANCE OF COIL IN MICRO HENRYS
HEIGHT OF COIL
CONVERSION LINE
REFERENCE LINE
5
4
3
2
1.5
⑦
80
90
100
110
120
130
140
150
160
170
180
190
200
250
300
350
400
450
500
550
600
700
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⑩
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100
90
80
70
60
50
⑪
3"
2"
1"
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.8
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.6
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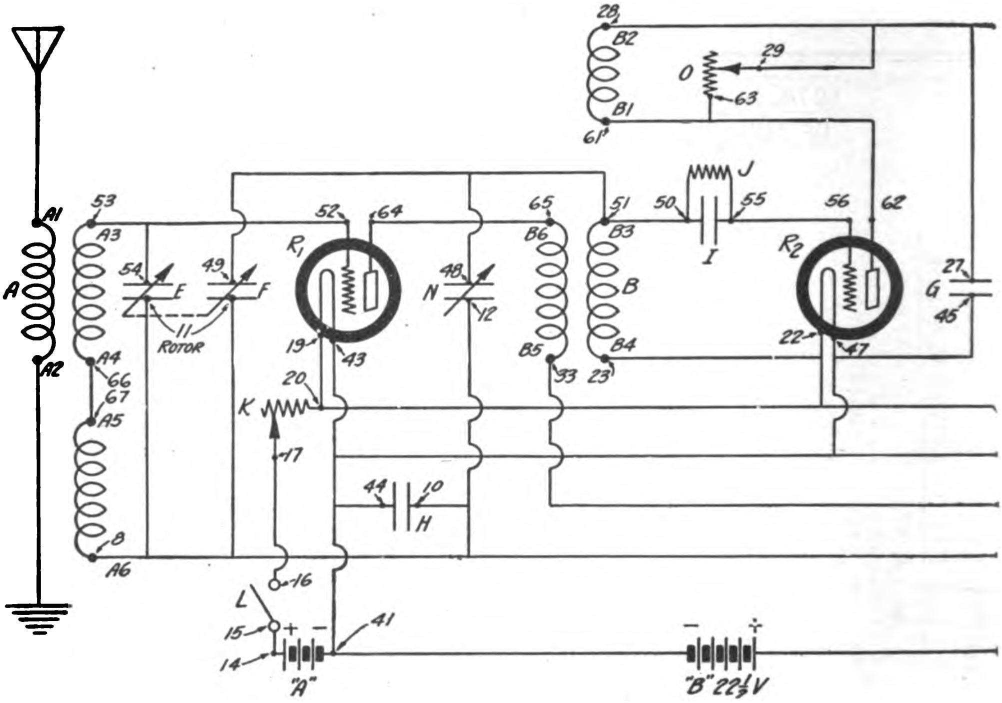
.4
3
.2
⑧



HOW TO BUILD

THE S-C RECEIVER

—*for short and long waves*

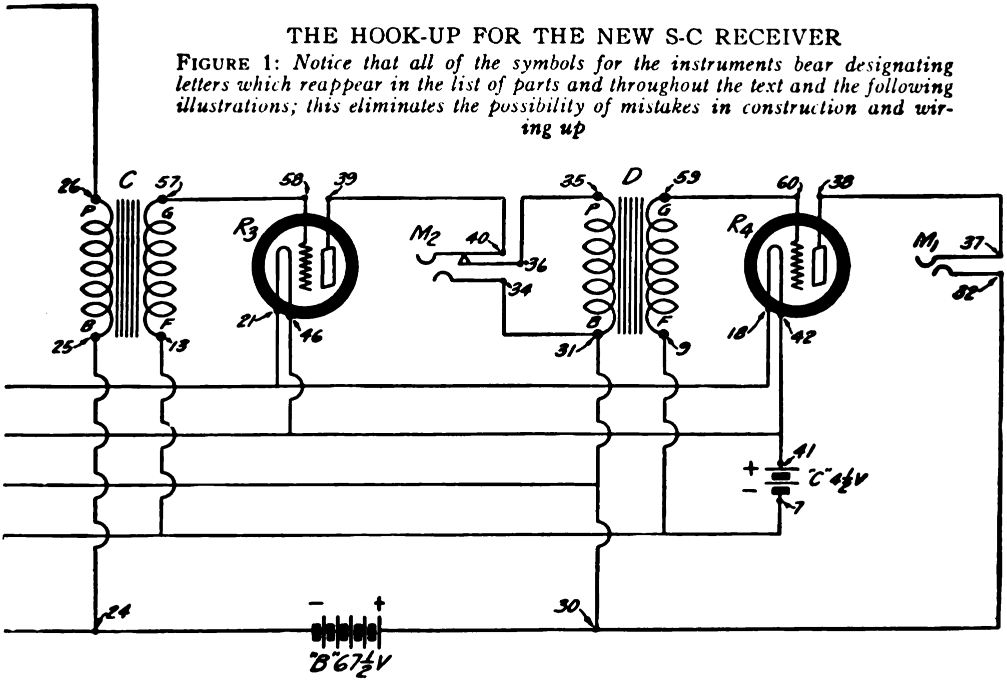
This new receiver covers wavelength ranges from 50 to 550 meters. This is the first time that a description of a receiver employing radio-frequency amplification with a regenerative detector for use over such wide frequencies has ever been described in any magazine. One exceptional feature of this receiver is that the wiring is done in advance, in the form of a "harness," and the whole receiver may be built in less than an hour. The qualities of volume, tone, distance reception and selectivity are exceptionally good.

By McMURDO SILVER and LAURENCE M. COCKADAY

COST OF PARTS: *Not more than $57.00.*
RECEIVING RANGE: *Coast to coast.*

HERE IS A LIST OF THE PARTS USED IN THE LABORATORY SET—

A and B—S-M antenna coil No. 110A and detector coil No. 114A equipped with two No. 515 coil sockets;
C and D—Thordarson No. R-200 transformers;
E and F—S-M SLF variable condensers No. 316 equipped with one vernier dial No. 801;
G—Polymet mica fixed condenser, .002 mfd.;
H—Polymet mica fixed condenser, .005 mfd.;
I—Polymet mica fixed condenser equipped with grid leak clips, .00015 mfd.;
J—Polymet grid leak, 2 megohms;
K—Yaxley rheostat No. 16K, 6 ohms;
L—Yaxley battery switch No. 10;
M1—Yaxley jack, type No. 1;
M2—Yaxley jack, type No. 2;
N—S-M Type No. 340 variable condenser, .000025 mfd.;
O—Centralab variable resistance, No. 25 M.S.R.;
P—Poster drilled and engraved front panel, 7 by 18 inches;
Q—Poster drilled and engraved sub-panel, 6½ by 17 inches;
R1, R2, R3 and R4—S-M tube sockets, type No. 510;
S1 and S2—No. 540 mounting brackets;
T—Hardwood cabinet for 7 by 18 inch panel;
U—Belden S-C connecting harness.



THE HOOK-UP FOR THE NEW S-C RECEIVER

Figure 1: *Notice that all of the symbols for the instruments bear designating letters which reappear in the list of parts and throughout the text and the following illustrations; this eliminates the possibility of mistakes in construction and wiring up*

¶ *The list of parts given here includes the exact instruments used in the laboratory set, from which these specifications were made up. The experienced amateur, however, will be able to pick out other reliable makes of instruments of similar characteristics and equal efficiency. But if the novice follows this list, the diagrams in this article will tell him exactly where to bore the holes and exactly where to place the connections. If instruments other than the ones used in the original model are used, the only change that will be necessary will be the use of different spacings for the holes that are to be drilled in the panel for mounting the instruments.*

THE development of the S-C receiver was undertaken by its designers with a number of definite ends in view. Possibly first was the development of a receiver for the home builder which would cover the entire wavelength band from 50 to 500 meters. Another important consideration was that the receiver should represent a far better dollar for dollar operating value than would any other design for this large wavelength band in points of selectivity, distance, range and tone quality, with four tubes.

It would be well for a moment to consider some of the special points incorporated in this design, in order that the prospective builder and experimenter may decide for himself whether or not it will satisfy him.

The first feature of the design is the absence of a multitude of tuning controls. All wavelength adjustment for tuning is done by a single dial, thus simplifying the operation of the receiver to a point where the absolute novice can operate it with the assurance of far more than average results. This feature is accomplished through the use of two standard condensers which are so designed that they lock into each other and thus permit of control from a single master dial. Needless to say, their design must be extremely accurate in order that any circuit variations will not affect the tuning of the receiver throughout its entire wavelength range other than to an extent which may be compensated for by a midget condenser which is employed for this purpose. This minor adjustment is not one that has to be made for each station tuned in, but rather, it is a single adjustment made initially in balancing the circuit. The substantially straight-line-frequency curve of the condensers used results in extremely easy tuning, as the low-wave stations may be so easily separated with no sacrifice in selectivity on the longer wavelength stations.

The wide tuning range of the receiver is accomplished by the use of special low-capacity, plug-in coil units. Thus, with two standard A type inductances, the wavelength range is from 190 to 550 meters. The range with two type B inductances is from 90 to 210 meters; the range with two type C inductances is from 50 to 110 meters. For the higher wavelengths used in European broadcasting two type D inductances will give a range from 550 meters to 1,200 meters. The type E coils will cover from 1,200

From a photograph made for POPULAR RADIO

TESTING OUT THE FINAL MODEL

FIGURE 2: *The authors are here shown putting the final model of the new receiver through its paces. They have checked up on its selectivity and tone quality as well as its distance-getting capacity and the amount of "B" battery comsumption, before giving it their approval.*

meters to 1,800 meters.* Due to the design of these coils, which are wound upon ribbed-bakelite tubing, the losses are extremely low.

The reader doubtless realizes that seldom is an all-wave design practical, yet in this particular receiver it has not only been made practical but it is perhaps the first time that radio-frequency amplification has been employed over such a wide range and with such satisfactory results.

The audio-frequency amplifier of this receiver represents another exceptional bit of engineering work on transformer design. A new type of power transformer, heretofore available only in receivers costing from $500 to $2,500 or more, is used. These transformers have practically a straight-line-frequency curve from 40 to 7,000 cycles. They are designed also for handling comparatively high powers without distortion.

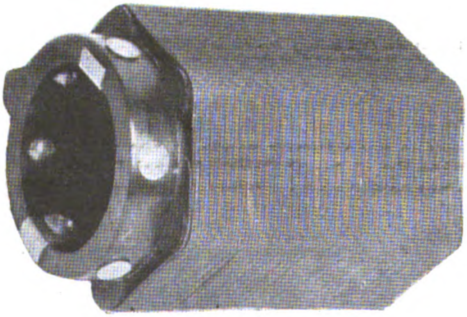


FIGURE 3: *The type of interchangeable coil used in the receiver.*

Another feature never before seen in home-constructed experimental receivers is the use of a wiring "harness" which simplifies the wiring to a point where anyone can assemble the receiver in less than an hour. This wiring "harness" or cable contains all the wiring in various colors, cut to the right lengths and assembled in one cable as shown in Figure 12. All low-potential leads, including battery connections, are contained in the cable so that it is merely necessary to compare the colors of the leads with the information given in the diagrams and connect the proper ones where they project from the cable to the instrument terminals that are numbered with the same numbers as marked in the photographs and drawings. The high potential leads of the grid and plate circuits of the radio-frequency amplifier and the detector are separate from the cable but supplied with it—cut to the proper length, with the ends scraped and tinned. Thus the wiring in this case is merely a simple process of pushing the ends of the cable through the holes in the baseboard and soldering them to instrument lugs or fastening them under the binding posts. This cable method of wiring is extremely efficient, for all the low-potential leads are grouped together and as a result, coupling to undesired parts of the circuit is reduced to a practical minimum.

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* In the list of parts only the type A coils are listed.

The circuit design is the standard four-tube circuit that employs one stage of tuned-radio-frequency amplification with variable coupling between the antenna and the grid circuit of the radio-frequency tube, a regenerative detector, with a resistance regeneration control and two stages of power-transformer amplification. Little more need be said of it, for in a recent survey of popular interest, it was found that this general circuit design was the most popular in the estimation of the home set-building public. The selectivity, sensitivity and quality of reproduction in this new receiver really is in excess of that of many five or six-tube receivers now available. While the S-C receiver does not represent the absolute limit of sensitivity or selectivity that may be realized by employing twice as many tubes in a carefully built receiver, it does represent the best dollar-for-dollar value available to the home-builder for a four-tube receiver, on account of its extreme flexibility and wide usage. The circuit design for the new receiver is shown in Figure 1.

Parts Used in Building the Set

In all of the diagrams used in this article, each part bears a designating letter; in this way, the prospective builder of a set may easily determine how to mount the instruments in the correct places and connect them properly in the electric circuit.

The same designating letters are used in the text and in the list of parts at the beginning of the article. (See page 258.)

How to Construct the Set

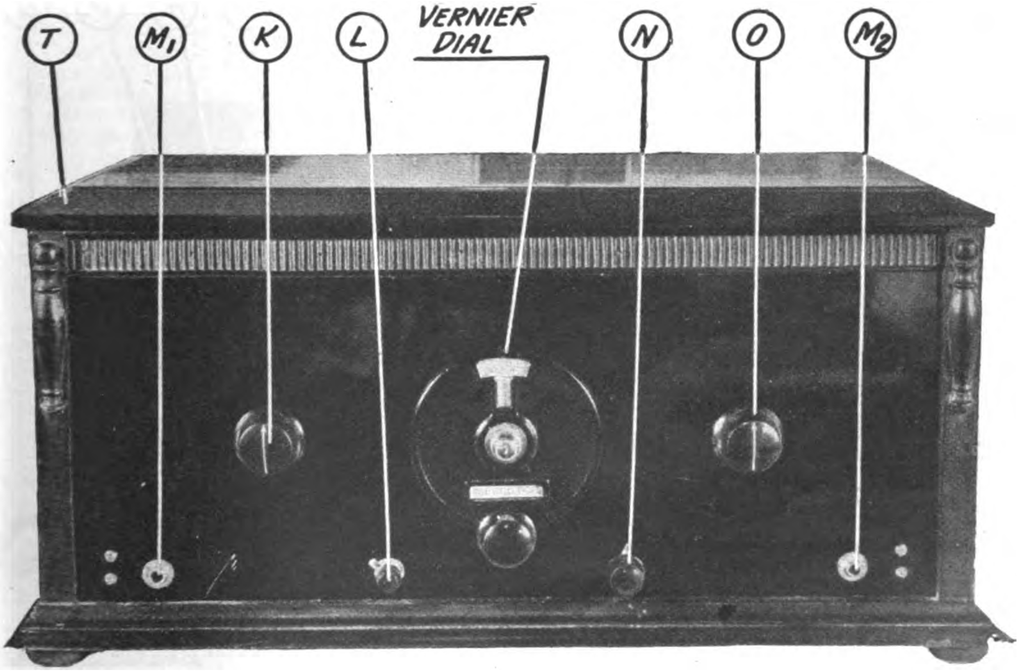
After procuring all the instruments and materials for building the set, the amateur should prepare the panel P, (shown in Figures 4, 5, 6, 7, 8, 9 and 10).

First of all, cut the panel to the correct size, 7 by 18 inches. Then square up the edges smoothly with a file. The centers for boring the holes (which are necessary for mounting the instruments) should be laid out on the panel as shown in Figure 11. A convenient method for doing this is to lay out all center holes on a piece of paper the same size as the panel; then the piece of paper may be fastened on the panel and the centers marked directly on the panel by punching through the paper with a sharp, pointed instrument.

If all the holes to be drilled are first started with a small drill, one-sixteenth of an inch in diameter or less, they may be more nearly centered.

The holes outlined with a double circle should be countersunk, so that the flat-head machine screws used for fastening the instruments are flush with the panel. All the rest of the holes are straight drill holes. Sizes for the diameters of these holes have not been given, but the builder will readily decide what size hole is necessary by measuring the diameter of the screws and shafts of the instruments that must go through the holes.

When the panel is drilled the builder may give it a dull finish by rubbing the face of the panel



THE FRONT VIEW OF THE RECEIVER

Figure 4: *As the dials and knobs are marked with letters which correspond to the instruments to which they are attached, the prospective operator will have no trouble in locating the various tuning controls, as they are explained in the instructions for tuning.*

lengthwise with fine sandpaper until it is smooth. This process should be repeated, except that light machine oil should be applied during the second rubbing. Then rub the panel dry with a piece of cheesecloth. A permanent dull finish will be the result. Or, the panel may be left with its original shiny-black finish, if care has been exercised, so that it has not been scratched during the drilling.

After the panel has been prepared the experimenter is ready to mount the instruments upon it.

If the specified drilled and engraved panel is bought, of course, this work will be unnecessary, as the drilling and finishing are already done by the manufacturer of the panel.

The sub-base Q may be prepared or bought already drilled as the experimenter may prefer. The drilling plan for this sub-base is also shown in Figure 11.

First of all, mount the coil sockets for the coils A and B in the proper places and fasten them to the baseboard Q with three screws to each instrument, as shown in Figures 5, 6, 7 and 8. It will be found that they fit exactly on the drilled panel. The proper positions for them are indicated in Figure 6, as determined by the position of the notches on the inner side of the socket rings. These are indicated in the photograph by arrows.

Next, mount the four tube sockets R1, R2, R3 and R4 in their correct positions as shown in Figures 5 and 6. They are fastened to the sub-base Q with a single screw to each instrument. Sockets R1 and R2 should be placed with the line that indicates the pin facing towards the back of the set and sockets R3 and R4 should be set with the straight line indicating the pin facing the front of the set. This is indicated in Figure 6 by small white line.

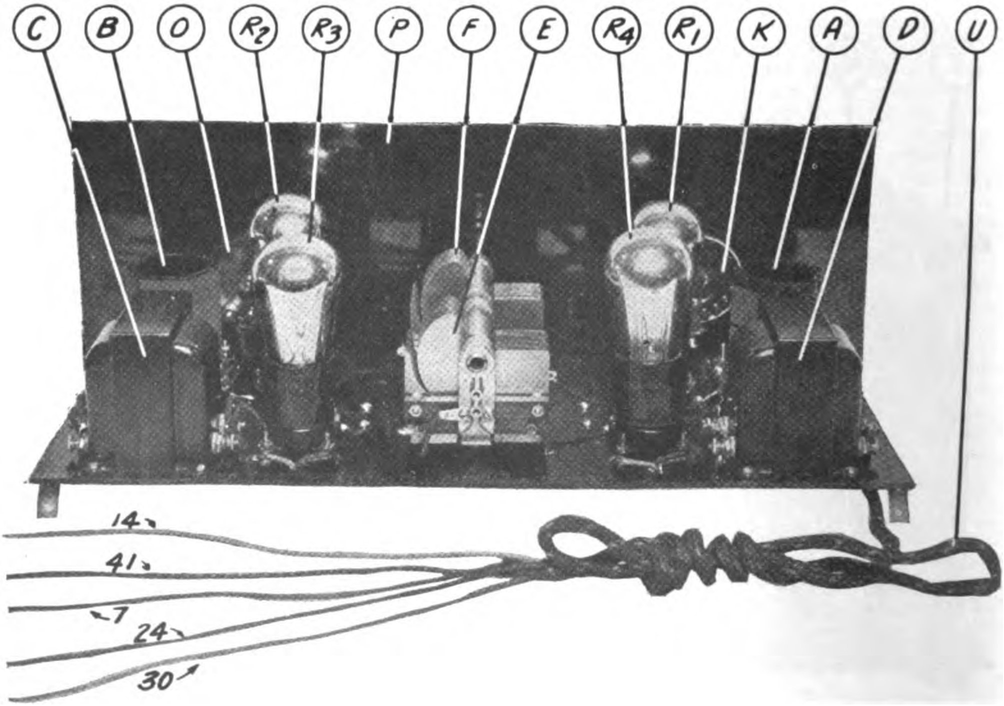
Next, mount the transformer C at the left-hand side of the sub-base and transformer D at the right-hand side of the sub-base (looking from the rear). The secondary terminals marked G and F should face in toward their respective sockets as may be seen in Figure 6. These large transformers should be mounted with four machine screws and nuts to each instrument.

Next, turn the sub-base upside down and mount the three condensers, G, H, and I in their proper positions by means of two screws and nuts through the holes in each instrument, as shown in Figure 9.

Then, insert the grid leak J in the clips on the condenser I.

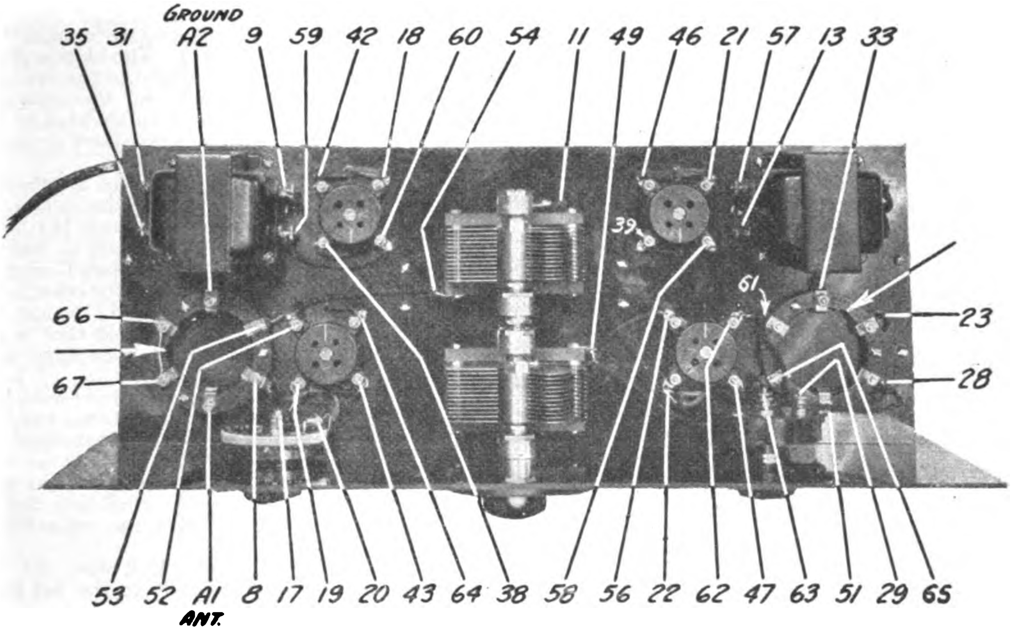
The next job will be to mount the two variable condensers, E and F, on the sub-base Q by means of two screws fastened through the sub-base up into the casting of the condensers themselves. This is also shown in Figure 6. Notice that the shaft of the condenser farthest from the main panel P is slipped into the bushing of the shaft of the front condenser where it is held fast by set screws.

The next job will be to mount the two brackets S1 and S2 one at either end of the bottom side of the sub-panel Q. These are fastened in place



VIEW OF THE SET FROM THE REAR

Figure 5: *This picture shows the general arrangement of all the instruments as they are fastened to the panel or base.*



VIEW OF THE SET FROM ABOVE

FIGURE 6: *This diagram will help you in your wiring, as it shows the terminals of the various instruments. They are designated by numbers that correspond with the numbers given in the text and with those that are attached to the various colored wires in the "harness" as indicated in Figure 12. (For instance, No. 35 wire in the harness would attach to the 35 terminal on the transformer D).*

with two screws and bolts to each bracket.

Next, mount the rheostat K on the right-hand end of the main panel P (looking from the rear). This is fastened with a single large nut on the shaft in the front of the panel. The indicating knob should then be attached to the shaft, as shown in Figures 4 and 5.

Then do the same thing with the 25,000 ohm resistance O at the left-hand end of the panel, as shown in the same Figures.

Now mount the two jacks, M1 and M2, in the proper position, as shown in Figures 4 and 9; and also mount the switch L and the midget variable condenser N, as shown in the same two Figures.

You are now ready to slip on the main panel over the shaft of the variable condenser and attach the four screws through the front of the main panel into the two brackets, S1 and S2 to make a firm assembly of both of the units P and Q. Then fasten the large nut on the shaft of the condenser F. This finishes the construction work and the set is now ready to be wired.

How to Wire the Set

By means of the novel S-C harness, the wiring of this set is practically all done in advance for the experimenter. Place the receiver "upside down" with the panel *facing towards the builder.*

Then take the connecting harness U that is illustrated in Figure 12 and hold it in your hands with the four battery connections numbered 7, 30, 24, 14 and 41 on the right. Then poke the first wires, which consist of a single maroon-and-red wire, No. 35, and a double red wire, No. 31, through the hole at the extreme upper right-hand corner of the sub-panel Q as you look down upon it.

Next solder the single brown wire, No. 37, to the right-hand terminal of the jack M1 as you look down upon it. Consult Figures 6, 9 and 11 frequently when doing the wiring up, as a check on your procedure. Then solder the double red wire, No. 32, to the left-hand terminal of the same jack. Next poke the double black wire, No. 9, through the adjacent hole in the sub-panel; and then poke the double black wire, No. 8, through the first right-hand hole in the sub-panel Q nearest the jack.

Then insert the yellow wire No. 19 and 20, the red-and-yellow wire, No. 17, and the double black-and-yellow wire, No. 43, in a group through the hole which is located near the hole for the No. 8 wire.

Then solder the single red-and-yellow wire, No. 16, to the terminal of the switch L which is nearest the sub-panel Q and also solder the yellow wire, No. 15, to the remaining terminal of this switch.

Next insert the double black-and-yellow wire, No. 42, and the double yellow wire, No. 18, through the hole which is out near the top edge of the sub-panel Q.

Then insert the short brown wire, No. 38, through the small hole in the sub-panel Q which lies right near the cable at that point. Next solder the double black-and-yellow wire, No. 44, to the far side of the condenser H. Then solder the triple black wire, No. 10, to the near side of the same condenser.

Now insert the black wire, No. 11, through the adjacent hole towards the top edge of the sub-panel Q. Then solder the double black wire, No. 12, to the right-hand terminal of the midget condenser N.

The next job will be to solder the double black-and-yellow wire, No. 45, to the far side of the condenser G. The maroon wire, No. 27, should then be soldered to the near terminal of the same condenser. Next insert the brown wire, No. 39, through the small hole in the sub-panel Q which lies near the far side of the condenser G. The double black-and-yellow wire, No. 46, and the double yellow wire, No. 21, should now be inserted through the large hole which is near the outer edge of the sub-panel Q at this point. Then insert the black wire, No. 13, through the adjacent hole in the sub-panel Q at this point.

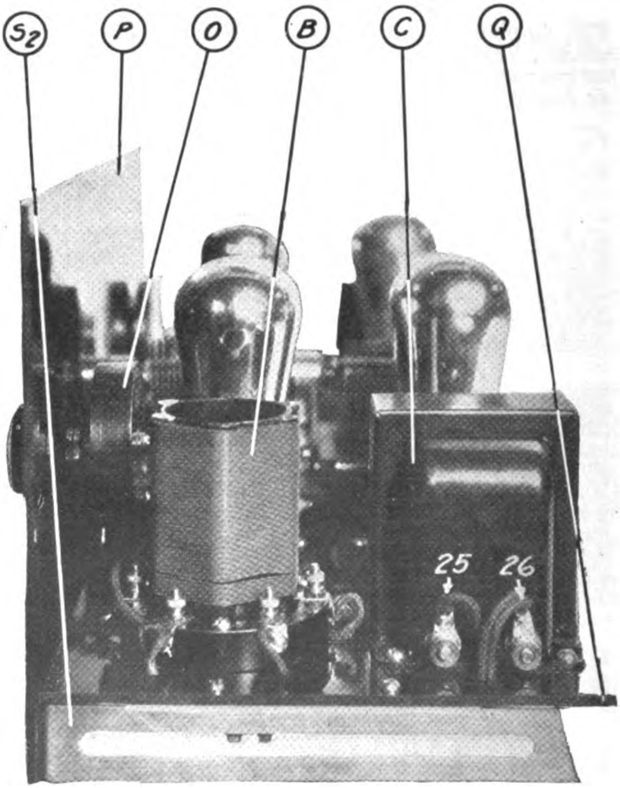
Now proceed to insert the single black-and-yellow wire, No. 47, and the double yellow wire, No. 22, through the large hole in the sub-panel Q, which lies nearest to the left-hand side of the small midget condenser N.

The next wire is a red wire, No. 33, and it should be poked through the small hole in the panel which lies near the right side of the end of the jack M2. Then solder the double red wire, No. 34, to the bottom right-hand terminal that lies nearest the sub-panel Q. The black-and-red wire, No. 36, should be soldered to the left-hand terminal of this same jack and the remaining brown wire, No. 40, should be soldered to the right-hand terminal of this jack, which is nearest the builder.

Next insert the yellow wire, No. 23, through the small hole in the sub-panel Q that is near the left-hand side of the end of the jack M2. The maroon wire, No. 28 and 29, should be inserted through the hole in the lower left-hand corner of the sub-panel Q that lies nearest the main panel P. The double maroon wire, No. 26, and the single maroon wire, No. 25, should then be inserted through the large hole in the upper left-hand corner of the sub-panel Q.

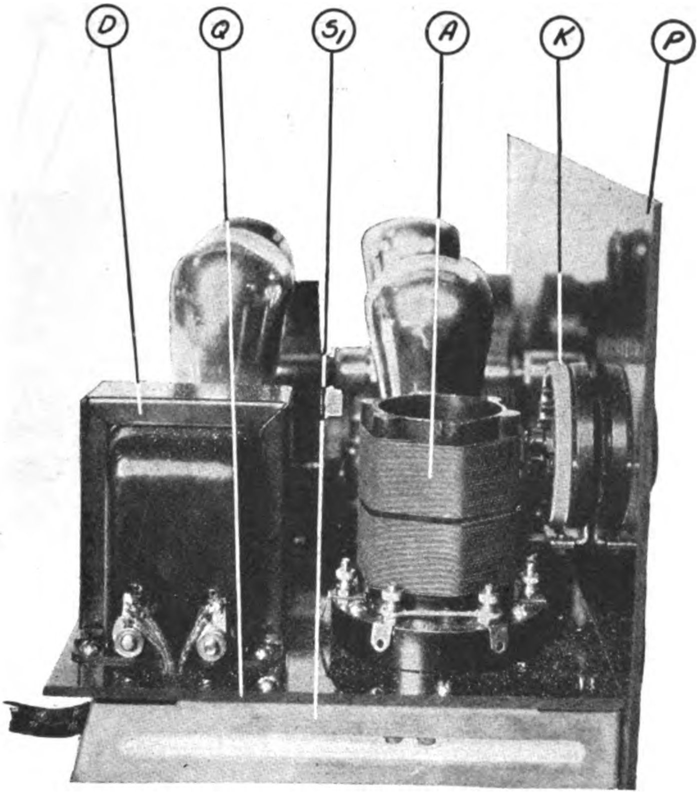
Next take the large separate maroon wire, No. 64 and 65, and solder one end of it to the terminal marked P of the socket R1. Slip it through the adjacent hole in the sub-base, towards the bottom side, and run along the bottom of the sub-panel Q and up through the small hole that is adjacent to the terminal B6 on the coil-socket B where it should be soldered.

Then, take the multiple black wire, No. 48, 49, 50 and 51, and solder it to the left-hand



VIEW OF THE RECEIVER AS SEEN FROM THE RIGHT END

Figure 7: *This shows the manner in which the sub-panel is fastened to a metal bracket and how the whole assembly is connected with the main panel. The general scheme for mounting the transformer and the coil is also given.*



VIEW OF THE RECEIVER AS SEEN FROM THE LEFT END

FIGURE 8: *This illustration shows the other end of the receiver and indicates the method of mounting the remaining coil and transformer and also the rheostat. Notice, in the left end lower corner, how the wiring cable comes out of the back of the receiver near the bracket and underneath the sub-panel.*

terminal of the midget condenser N, as you look down upon it with the set upside down. Then run the connection, No. 50, over to the near end of the condenser and grid leak I and J, respectively.

Then insert the remaining ends, No. 49 and 51, of this wire through the small hole which will be found in the sub-panel Q at the left-hand side of this same condenser. Then turn the set the other way up and solder connection No. 49 to the left-hand terminal on the stator of the condenser F, which is adjacent to this hole. Then run the remaining terminal, No. 51, of this same wire over to the terminal B3 on the coil-socket B and solder it fast.

This completes all the wiring that runs to terminals below the sub-panel Q.

Now take the small black wire, No. 55 and 56, and attach one end of it to the terminal G on the tube socket R2 and run it over to the screw that attaches to the remaining terminal of the condenser I and the grid leak J. (This is one of the screws that holds this condenser on to the bottom of the sub-panel Q. It is the opposite terminal to the one you have already connected wire No. 50 to.)

Next, take the short black wire, No. 57 and 58, and run it between the terminal G of socket R3 and terminal G of transformer C. Then connect the small black wire, No. 59 and 60, between the terminal G of socket R4 and the terminal G of transformer D.

Then pick out the black wire, No. 52, 53 and 54, and connect the long bare end to terminal A3 of coil-socket A and connect this same end to the terminal marked G on socket R1. The remaining end, which is No. 54, should be connected to the nearest stator terminal of condenser E.

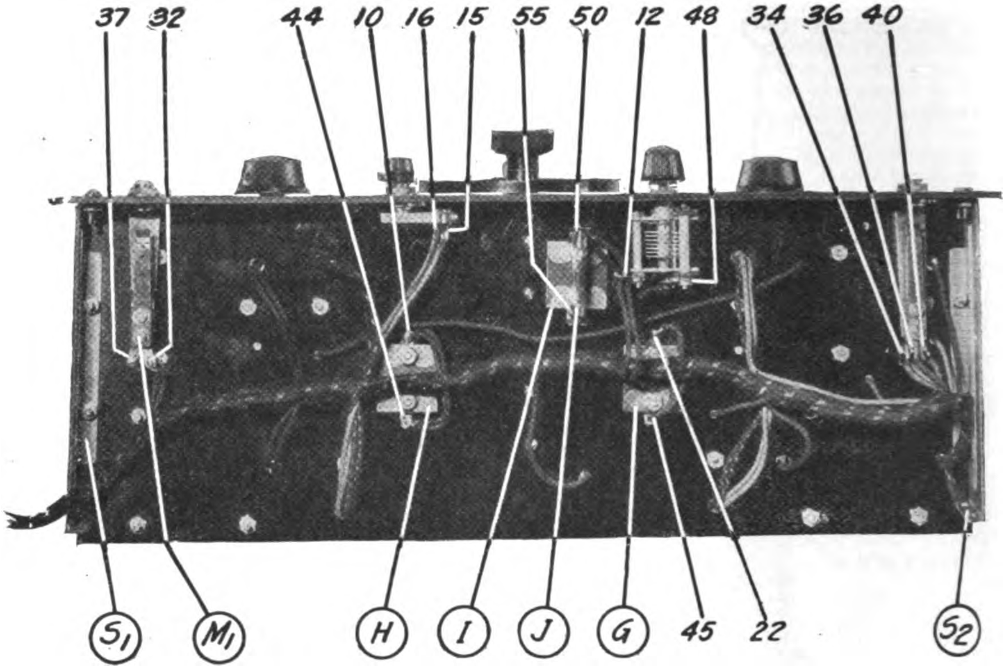
Next take the maroon wire, No. 61, 62 and 63, and connect the large bare end to terminal P on socket R2 and terminal B1 on socket coil B. Then run the opposite end of this wire, which is No. 63, to the lower right-hand terminal of the resistance O.

Then, connect terminals A4 and A5, on coil-socket A, with a black wire, No. 66 and 67.

This completes the wiring of the separate pieces on the top of the panel and you are now ready to connect up the rest of the cable ends which were previously projected upward through the holes in the sub-base Q.

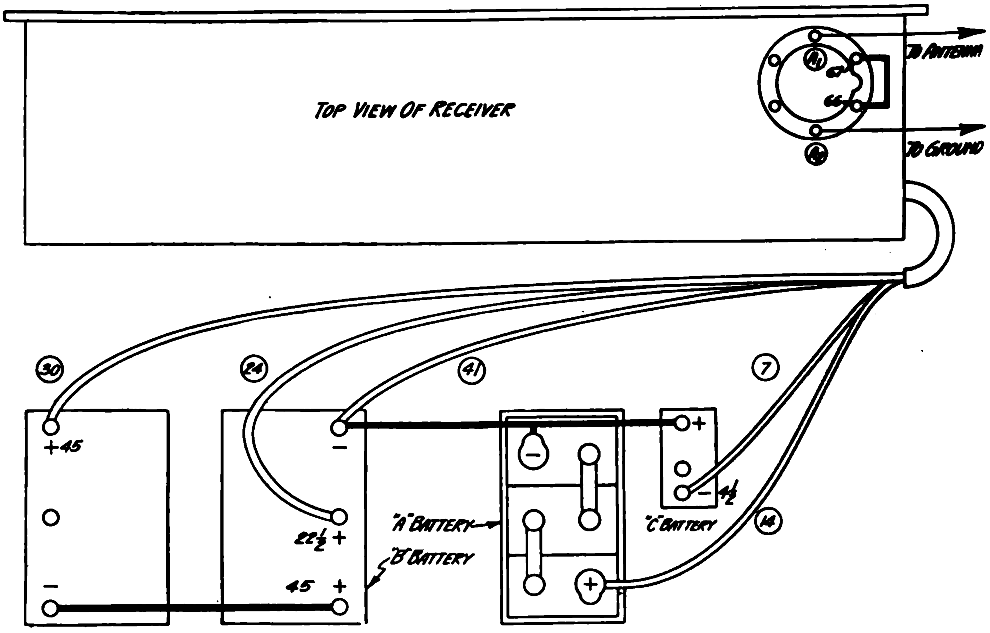
Start connecting this up in the following manner:

Connect the double black wire, No. 8, to the



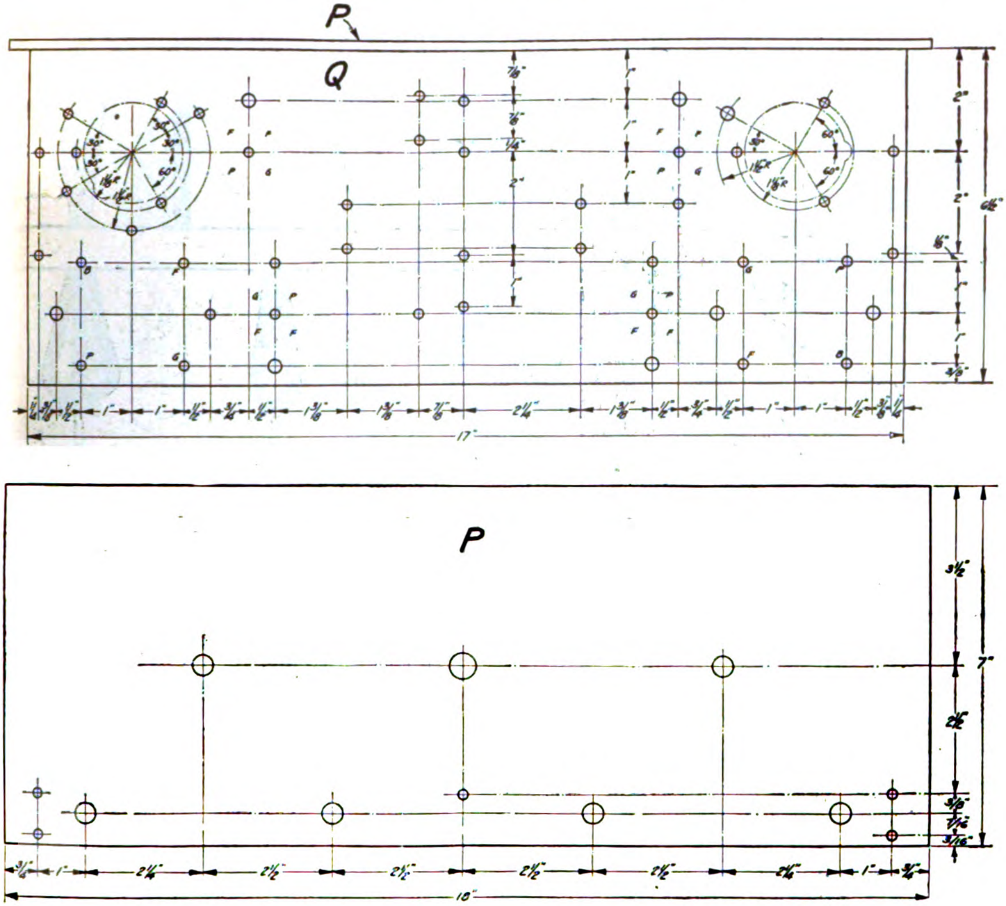
VIEW OF THE RECEIVER FROM UNDERNEATH

FIGURE 9: *This diagram will be found of help in wiring up, as it shows the connections for the terminals of the "harness" below the sub-base. They are numbered with designating numbers that refer to the instrument terminals as well as to the colored wires themselves.*



HOW TO HOOK-UP THE BATTERIES AND THE AERIAL AND GROUND

FIGURE 10: *This drawing prevents the builder from making mistakes in connecting the batteries to the terminals of the "harness" or battery cord. Follow these instructions and the set will be hooked up correctly because the terminals shown here and in the "harness" diagram in Figure 12 are marked with the same numbered designation.*



THE DRILLING PLANS

FIGURE 11: *The top drawing gives the drilling dimensions for the sub-panel Q and lower drawing gives the drilling dimensions for the main panel P. These drawings show where to drill the holes for mounting the instruments and for the holes in the sub-base that the wires are inserted through. The correct spacings are given for all the holes.*

terminal A6 on the coil-socket A. Then connect the single yellow wire, No. 19 and 20, to the right-hand terminal F of socket R1, and to the bottom terminal of rheostat K. Then, connect the single red-and-yellow wire, No. 17, to the left-hand terminal of the rheostat K. Next connect the double black-and-yellow wire, No. 43, to the left-hand terminal F of socket R1.

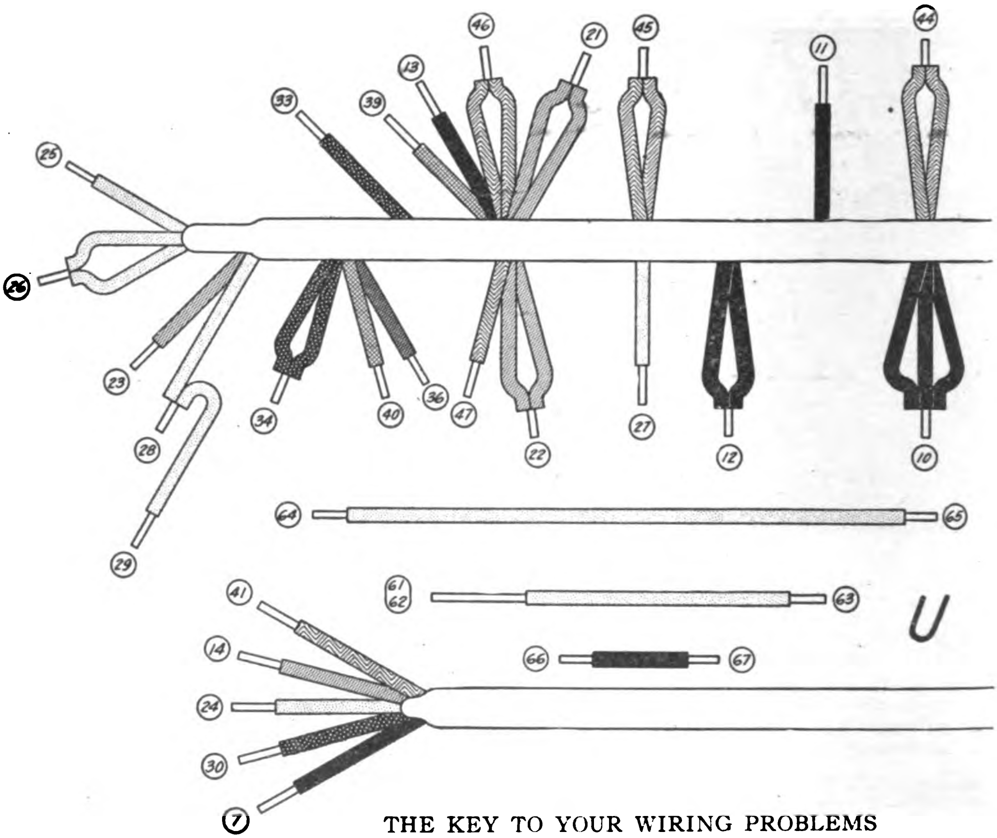
Next connect the single brown wire, No. 38, to the terminal marked P of socket R4. Then connect the double yellow wire, No. 18, to the left-hand terminal marked F of socket R4. Also connect the double black-and-yellow wire, No. 42, to the right-hand terminal of socket R4. Then connect the double black wire, No. 9, to the terminal marked F on transformer D. All of these wires will be found coming through the sub-base Q at holes adjacent to the instrument terminals, just where you previously placed them. Next connect the single red-and-black wire, No. 35, to the terminal marked P of transformer D. Then connect the double red wire, No. 31, to terminal marked B on transformer D.

The next wire to be connected is the single black wire, No. 11, which should be connected to the common rotor terminal for condensers E and F.

The next job will be to connect the double black-and-yellow wire, No. 46, to the right-hand F terminal of socket R3. Connect the double yellow wire, No. 21, to the left-hand F terminal of the same socket. Then solder the single brown wire, No. 39, to the terminal marked P on the same socket.

The next task will be to connect the single black wire, No. 13, to the terminal F on transformer C. Then connect the double maroon wire, No. 26, to the terminal marked P of this same transformer. Connect the single maroon wire No. 25, to the remaining terminal marked B of this transformer.

Now connect the double yellow wire, No. 22, to the right-hand F terminal of socket R2. Then connect the single black-and-yellow wire, No. 47,



THE KEY TO YOUR WIRING PROBLEMS

Figure 12: *This drawing shows in diagrammatic form the "harness" for the new S-C receiver. All of the wires are numbered with the same numbers as the terminals that they go to, on the receiver parts themselves. The legend printed at the left gives an indication of the various colors that you will find in the harness. The smaller wires that are separate from the harness you will find in the same package with the harness itself. These are used for plate and grid connections.*

LEGEND

- Maroon □
- Yellow ▨
- Red ■
- Brown ▩
- Black ■
- Red With Black Tracer ■
- Black With Yellow Tracer ▨
- Yellow With Red Tracer ▩

to the left-hand terminal of this same socket.

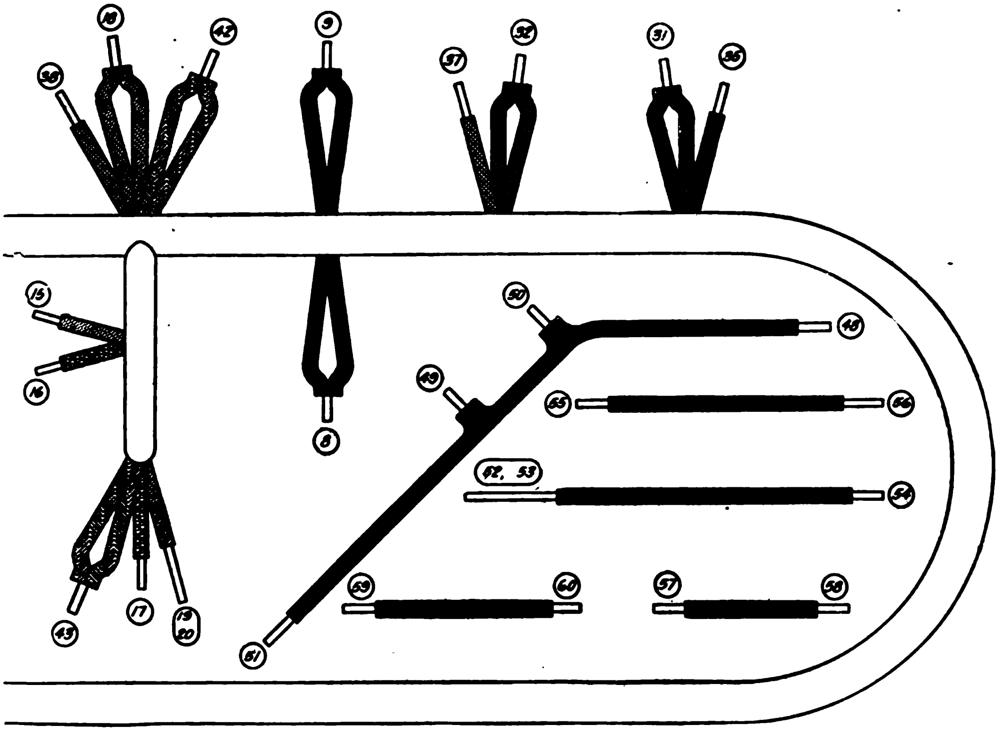
Another connection that may now be made is to solder the single red wire, No. 33, to terminal B5 on the coil-socket B. The single yellow wire, No. 23, may now be soldered to terminal B4 on the same coil-socket.

The last connection which must be made before the job is finished is the maroon wire and this should be fastened with terminal No. 28 connected to terminal B2 on the same coil-socket. At the other end of this wire will be found connection point No. 29 which should go to the left-hand, bottom terminal of the resistance O.

This completes the wiring and you are now ready to install the receiver.

How to Install the Set

Before placing the set in the cabinet, which may be any standard cabinet for a 7 by 18 inch panel, the tuning dial (No. 801) should be attached to the gang condenser. The dial should be examined first to make sure that the indicator plate, visible through the aperture at the top, is reading on the "zero-to-100" scale rather than the "200-to-zero" scale, which is on the opposite side. This can easily be adjusted properly by merely loosening the nickel-plated center stud holding the indicator disk in place. This disk will drop out if the control knob of the dial is pulled away from the center slightly. The indicator disk may then be turned so that its "zero-to-100" side will be visible through the aperture. It can be pushed into place by merely moving it in its cavity in the dial housing. Pulling the control knob away from the center will cause the indicator disk to drop



down and engage with the small friction-drive stud of the control-knob mechanism. The nickle-plated center stud may then be screwed up tight and the dial is ready for use. It should then be placed over the condenser shaft at the center of the panel in such a fashion that the small locking pin of the dial, located below the control knob, will fit into the small hole intended for it in the panel, which will prevent the dial from turning. Both condensers should be turned so that their plates are entirely interleaved and so that when viewed from the front, the edges of the rotor plate section are just even with the top edges on the left-hand side of the stator plate sections, where they are not cut away. The condensers may be easily locked together by means of the set screws found at the rear end of the rotor bushing of the front condenser F. The dial is then locked to the condenser shaft by tightening up the set screw in the nickle-plated center piece, being sure that the dial reads zero against its indicating mark when both condensers are entirely interleaved. Should it be found that the two condensers, when locked together, move stiffly, the rear bearing of the front condenser F should be loosened up by unlocking the lock nut, giving the bearing sleeve one turn counter-clockwise so that it will not bear against the rear of the rotor-plate bushing, and relocking the nut on this bushing against the condenser frame. In this way only three bearings will be actually in use for the two condensers—more than are actually necessary for good mechanical operation.

The knobs on the rheostat K and the volume-control resistance O should be tightened up on the instrument shafts with a small screw-driver so that the heads of the arrows will fall directly over the contact arms that are visible at the rear of the instruments.

The small balancing condenser, below at the right of the control dial, should have its plates turned *all the way in* and the pointer screwed up on the shaft until it points straight to the right. Then the small knobs supplied with this condenser should be screwed up until it locks the pointer in this position. Thus the pointer will be at the left when the plates are entirely "out" and at the right when the plates are entirely interleaved.

Then the set may be put into the cabinet and fastened in place. A hole should be drilled in the back of the cabinet for the battery-end of the cable, so that the batteries can be connected.

Connect the batteries and the aerial and ground connections exactly as shown in Figure 10. Next insert in the four tube-sockets, R1, R2, R3 and R4, four UX-201-a tubes, or you may insert three UX-201-a tubes in sockets R1, R2, and R3 and one UX-112 in socket R4, for greater volume.

Be sure that the pins on the tubes are turned towards the small lines on the socket as indicated in Figure 6, by the white lines.

To become acquainted with the set, it will be best to start now to tune in a few local stations. Turn the switch L so that the filaments light up when the rheostat K is rotated in a clockwise direction. Then insert the loudspeaker plug in jack M1 or the phones in jack M2 for tuning.

In preliminary tuning of the receiver, the balancing condenser should be turned entirely to the

A Tuning Chart to Adjust to Your Own Set

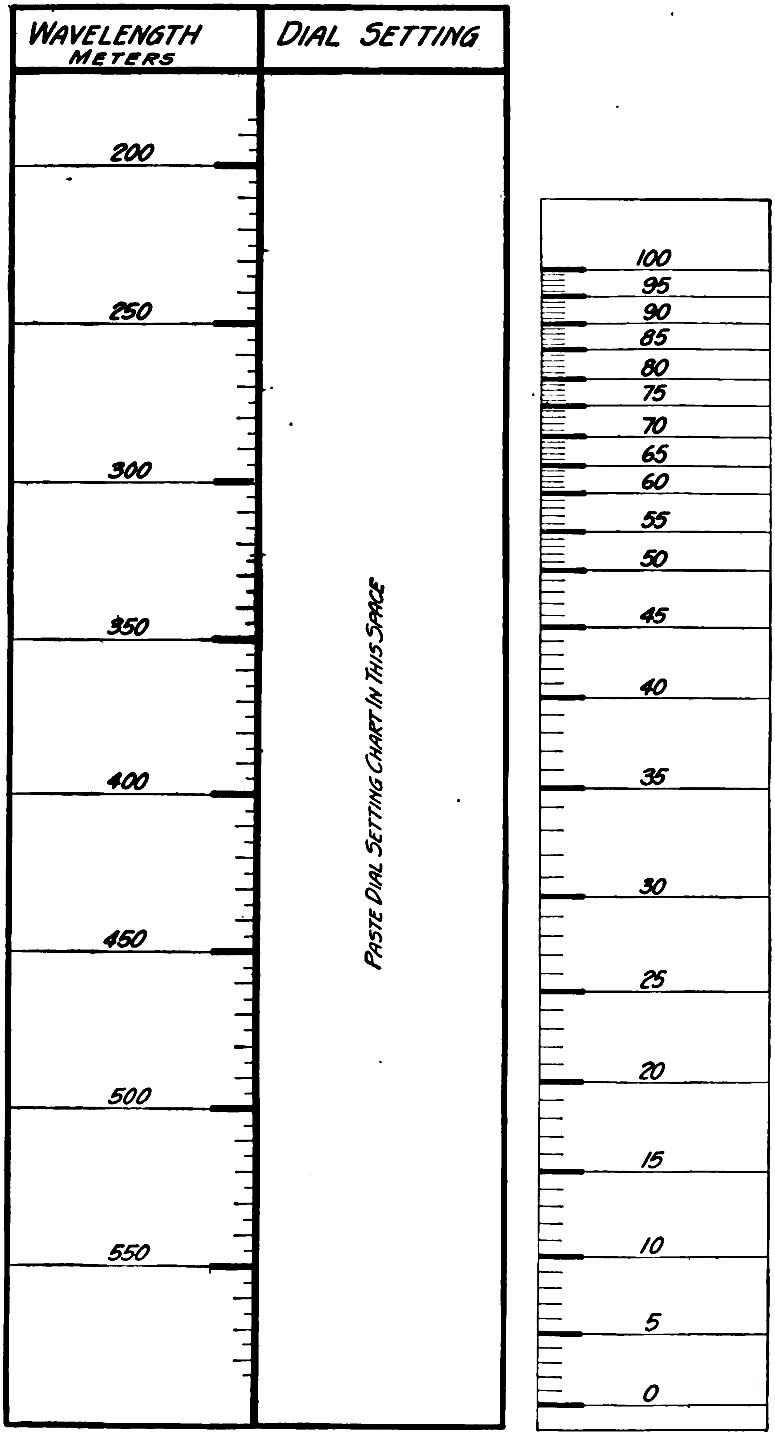


FIGURE 13:

Cut out the chart at the left and paste it on a piece of thin, stiff, white bristol paper. Then cut out the small chart at the right. It should be pasted in position on the blank space on the right side of the main chart underneath the heading "dial setting." To get it in exactly the right position, tune in a station of around 350 to 400 meters and find out what setting it comes in on on your dial. For instance, a station on 405 meters would come in somewhere near 30 to 35 on your dial according to the variation of the condenser in the set. If it comes in at 32 (say), paste the wavelength part of the chart in place so that 405 meters on the wavelength scale is exactly opposite 32 on the dial setting scale. Then all the other stations will tune in approximately as indicated by the completed chart.

left and all tuning should be done with the large center dial. If it is noticed that stations appear to come in at two points on the central dial, say from one-half to two degrees apart, this can be overcome by adjusting the small balancing condenser from left to right until the stations come in at only one sharply defined point. If adjusting the balancing condenser does not overcome this difficulty, then the set-screw that locks together the two tuning-condenser rotor assemblies, should be loosened and their position with relation to each other changed in such a fashion that when the rear condenser E is so set that its rotor-plate edges are on a line with the left edges of its stator plates, the rotor-plate edges of the front condenser F will be slightly below, say not over one-eighth of an inch at their periphery, the left edges of the front condensers' stator plates.

After this adjustment has been once made, all the tuning will be done with the main dial and the resistance O will be used to control regeneration. Turning this resistance in a clockwise direction will increase regeneration and turning it in the opposite direction will decrease regeneration.

The two inside rotatable coils in the coil units A and B should be adjusted for maximum signal strength, with the proper degree of selectivity, and for the proper amount of regeneration that can be controlled by the resistance O.

The rotor of the coil A should be reversed a few times until the best signal strength and the best selectivity is obtained. This can be done by inserting the finger down into the coil and turning the small rotor a little bit at a time until the correct setting is found.

The same applies to the regenerator tickler mounted inside of coil B. This should be rotated until it is in the right position and until the maximum signal strength is obtained, with a smooth control of regeneration. In Figure 13 is given a tuning chart that will show approximately where to set the dial for various wavelengths. Once a station is located its volume may be improved by setting the control O for the best signal strength.

It is recommended that a cone-type of loud-speaker be used with the set. In the final analysis, results are the deciding factor in whether a receiver design will be popular and will continue to be regarded with favor. On the night of December 28, at the home of Mr. Laurence M. Cockaday in a residential section of New York City, between nine and ten o'clock, some 34 stations were logged with the four tubes, on a loud-speaker, without the use of headphones. Slightly later, when KFI came on, this station approximately 2800 miles away was brought in, to a crowded metropolitan area, with sufficient volume to be heard throughout two good-sized rooms.

The adaptability of the general design, assembled as it is on a 7 by 18 inch bakelite panel and a 7 by 17 inch bakelite sub-base, is astonishing. It may be placed in any type of console cabinet or any other standard enclosure or, it may even be put in a portable case, since the receiver will operate with a small antenna—or with a long one with equal selectivity—say, anywhere from 20 to 150 feet. If it is desired to receive the lower wavelengths, the short-wave coil sets should be installed in place of the two that are given in the list of parts accompanying this article. The tuning with these, however, remains the same for any wavelength range.

The set is easily put together in less than an hour and will be found to be extremely selective, with great sensitivity, and fine tone quality.

Kadel & Herbert

THE "FIRST PRIZE RADIO DRAMA" IS PRODUCED

A few months ago station WGBS of New York offered a prize for the best play written for production before the microphone. The winning script was entitled "Sue 'Em," and it was recently given first presentation by the Provincetown Players in the studio of WGBS and was simultaneously broadcast from WIP and WGY.

IN THE WORLD'S LABORATORIES

CONDUCTED BY DR. E. E. FREE

Does the Moon Affect Radio?

In the early days of broadcasting there was a common opinion that distant reception was related in some way to the phases of the moon. Most radio engineers put this down as superstition, although there were a few enthusiasts who took the matter seriously enough to keep records which proved (as might have been expected) to indicate nothing very definite. In those days distant reception was more or less a happy accident anyway. Any effects which the moon may have had on distant radio were covered up by other variables.

It seems, however, that one British amateur has been keeping careful records more recently. The results are reported in a recent note by Mr. W. J. Turberville-Crewe,[*] who suggests that other observers do likewise. The one series of records available suggests that distant reception is better when the moon is on the wane than when it is increasing.

Curiously enough, there are at least two ways in which the moon actually might influence the behavior of radio waves. One of these is by some magnetic action. The other is by the action of moonlight on the ionization of the atmosphere.

The magnetic field of the earth is not an invariable thing. On the contrary there are well known alterations in the intensity and direction of the magnetic forces with the hour of the day, the day of the month, and the like. Some of these variations are believed to be due to the sun, to the seasons and other factors but when all such have been eliminated there remain some variations which can be correlated only with the moon. The latest student to examine these lunar magnetic effects reports that they may be best explained as due to a tide created by the moon in the atmosphere of the earth, thus displacing the ionized zone which we call the Heaviside Layer.[‡] Undoubtedly, this would somewhat affect radio as well as earth magnetism.

Moonlight, too, would have an effect somewhat similar to the effect of sunlight, although proportionately weaker. It would tend to ionize the upper air, thus affecting once more the properties of the Heaviside region. Furthermore, the light of the moon is partly polarized light. Its vibrations tend to be all in one plane instead of in all possible planes, as is the case with sunlight. There is some evidence that polarized light is a more effective ionizer than is ordinary light of the same intensity.

All in all, the suggestion of Mr. Turberville-Crewe may be heartily seconded. A number of carefully kept diaries, showing the measured intensity of reception of selected distant stations as related to the position and phase of the moon might yield some interesting information.

Solving Antenna Problems by Small-Scale Models

The problem of how much energy will be radiated by the antenna of a broadcasting station or by any other transmitting antenna is not only one of the most important of practical radio problems; it is also one of the most difficult to solve. The radiation is specified, of course, by the general laws of electro-magnetic fields, but unfortunately the mathematic expressions for the complicated antenna systems now in vogue are so involved and difficult that only a very few cases have yielded, so far, to the analytic skill of the mathematicians. And to experiment extensively upon the properties of actual, full-size antenna systems involves the long-continued use of installations which are urgently needed, in most cases, for commercial use.

Thus arises the desirability of being able to experiment on radiation from small-size model antenna systems. That this is possible has been suggested by many radio engineers. Over three years ago an actual investigation was begun by Professor J. Tykocinski-Tykociner of the University of Illinois. The results of this investigation are now published in detail* and constitute an interesting and useful chapter of radio research.

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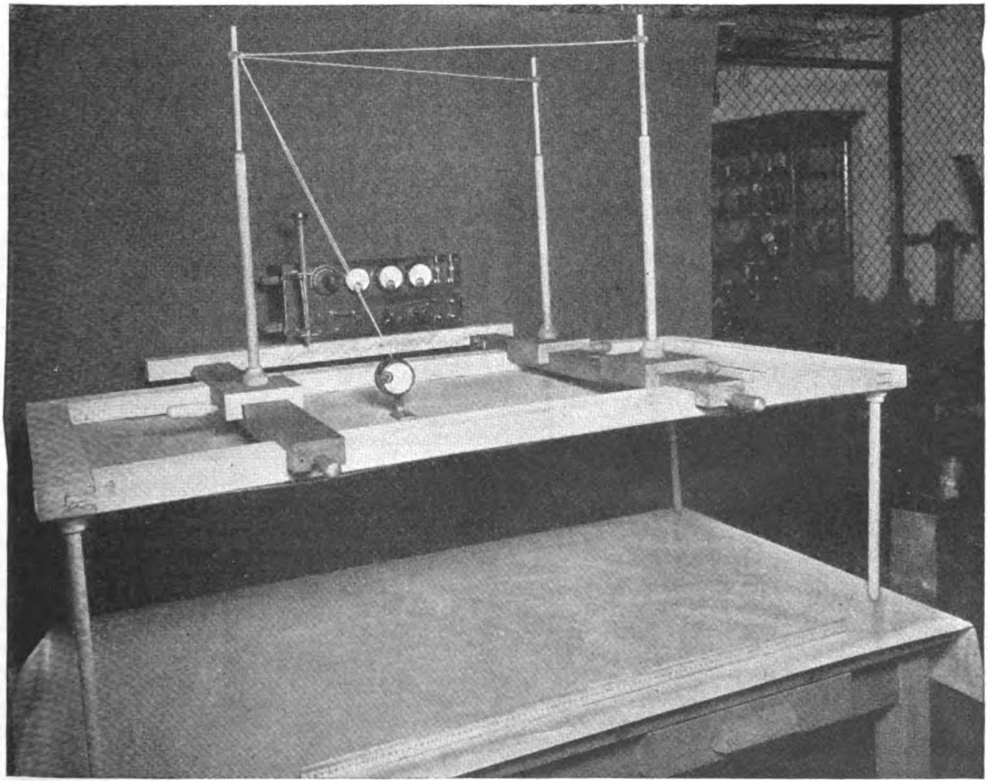
[*] "Wireless, the Moon and the Barometer," by W. J. Turberville-Crewe. *Experimental Wireless* (London), vol. 2, page 901 (November, 1925).

[‡] "The Lunar Diurnal Magnetic Variation at Greenwich and other Observatories," by S. Chapman. *Philosophical Transactions of the Royal Society* (London), vol. 225, pages 49-91 (April 17, 1925).

The investigation depends upon the principle, which Professor Tykociner establishes both theoretically and experimentally, that the behavior of an antenna system is practically the same so long as the ratio between its linear dimensions and the wavelength of the oscillations used is constant. For example, a three-foot antenna of a certain design, energized by a three-meter wave, will behave like a three-hundred-foot antenna of the same design energized by the three-hundred-meter wave of a broadcasting station. The small antenna may be used to test the radiation or other properties. Conclusions thus obtained may then be applied to the design or operation of the larger system used with ordinary waves.

Professor Tykociner's experiments have been carried out, in the main, with model antennas energized with waves between three meters and six meters in wavelength. These waves were produced by vacuum-tube circuits showing considerable ingenuity in arrangement but not essentially different in principle from other circuits arranged for the generation of ultra-short waves. The radiation from the model antenna systems and the losses and other features of such systems were measured, also, according to methods now in standard use for waves within this same high-frequency range.

There is an instrumental novelty, however, in the form of a new variable condenser, designed for extremely short waves and which is said to obviate many of the well-known difficulties in using ordinary condensers with waves shorter than ten meters. The new condenser consists of two fully circular plates each of which is broken, along a diameter, by a small offset, like the step of a stair. When the rotor plate is rotated, the proportion of the two plates which is farther apart by the amount of the offsets is increased or decreased, thus altering the capacity by a small amount and without as much disturbance from the body capacity of surrounding objects as is inevitable with condensers of



A SMALL-SCALE MODEL OF A FLAT TOP ANTENNA

By this model and others like it Professor Tykociner, of the University of Illinois, has been able to study the properties of different antenna systems without building complete full-size antennas. Very short waves are used, so that the small antenna will behave as does a large antenna using longer waves.

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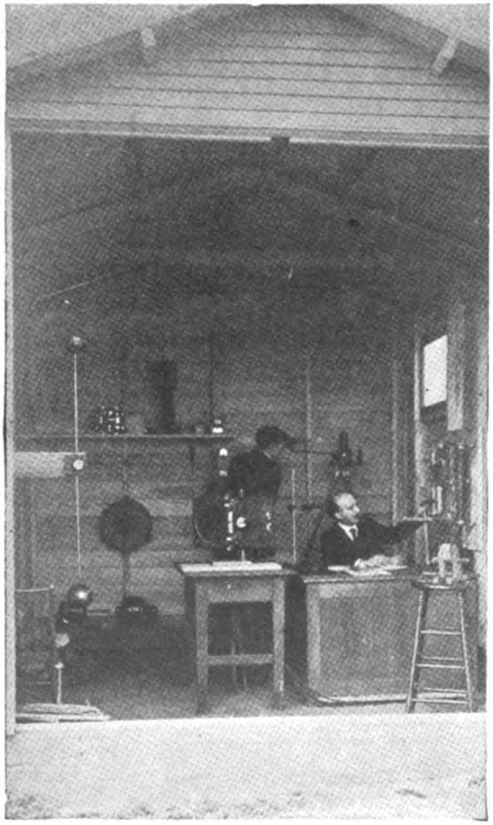
*Preliminary reports were made before scientific meetings in 1923 and 1924. The full report is entitled, "Investigation of Antennae by Means of Models," by J. Tykocinski-Tykociner, published as Bulletin number 147 of the Engineering Experiment Station of the University of Illinois, Urbana, Ill., 60 pages, issued May 25, 1925, price 35 cents. We are indebted to Professor Tykociner for the photographs reproduced herewith.

more usual design. The wavemeter used with the apparatus consists of one of these condensers mounted with an inductance consisting of a single loop of brass strip.

The whole system of short-wave generator, instruments and model antennas has proved valuable, Professor Tykociner reports, both in radio instruction to students and in the practical study of antenna problems. It is probable, too, that it would prove useful as equipment for fundamental researches in wave radiation and propagation. Amateur experimenters searching for new worlds to conquer in radio research are recommended to study Professor Tykociner's experiments and to consider building some similar small-scale models of their own.

Mine Finding by Science

The hope that radio waves might be put to practical use in exploring the rocks of the earth and in finding valuable minerals or veins of precious ore has been disappointingly slow of fruition.* This possible application of radio is still in the stage of discussion and hopes. The difficulty appears to be that much fundamental scientific work must first be done merely for its own sake and without hope of immediate reward. No one has been found to do this. It is easier—and more profitable—to construct some complicated and impressive modification of the old-fashioned, and useless, divining rod.



AN ANTENNA LABORATORY

Here is where Professor Tykociner (seated at the desk) and his assistant, Mr. L. P. Garner, have carried out their studies with model antenna systems.

However, there does appear to be important progress in the use of another method of underground exploration, that by gravity. Geologists have known for many years that the force of gravity at the earth's surface is not everywhere the same. Some parts of the earth appear to be underlain by heavier rocks, other parts by lighter rocks. The differences are slight, far too slight to be detected by ordinary scales. Nevertheless, they can be detected by delicate instruments, especially by a device known as the Eötvös balance. The use of this balance is slow and laborious but it is possible by its aid to map the intensity of gravity over any desired part of the earth's crust.

It has been found that such a gravity map supplies a certain amount of data of value in infering the existence of underground mineral deposits.‡ For example, salt has a lower density than most rocks. Above a salt deposit there will be a slight decrease of gravity. And, since salt is sometimes associated with a certain kind of oil deposit, this fact may be useful in prospecting for oil. The method is now in use and has proven of some value although in this case, as with the radio methods, the need is for much additional scientific information before practical application can be direct and perfect.

It is a pity that among the hundreds of organizations and individuals who annually spend millions in searching for new mines none can be found to undertake the scientific study of the radio possibilities. There could be no guarantee of financial profits. Profits often dodge the scientific pioneers and find a lodging elsewhere. But there would be, at least, the consciousness of having done a worth-while job for radio science.

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*For an account of some possibilities, see: "Finding Mines by Radio," **Popular Radio** for September, 1924, pages 238-245.

‡The Eötvös balance and other modern devices for scientific prospecting are described briefly in a recent article entitled "Buried Treasure," by Albert G. Ingalls, *The Scientific American* (New York), vol. 133, pages 392-393 (December, 1925).

What Pushes a Wheelbarrow?

Sir Oliver Lodge is unique among scientific men in his gift for finding the picturesque phrase. He has done it again. In the Norman Lockyer Lecture on "The Link between Matter and Matter," delivered before the British Science Guild on November 16, 1925, he urged upon the scientists there assembled the fundamental profundity and importance of so simple a question as that of what pushes a wheelbarrow.

"I am going to suggest," he said, "that the pressure of light may have to be taken into account before the most ordinary operations of daily life, even the propulsion of a wheelbarrow, are properly explained."*

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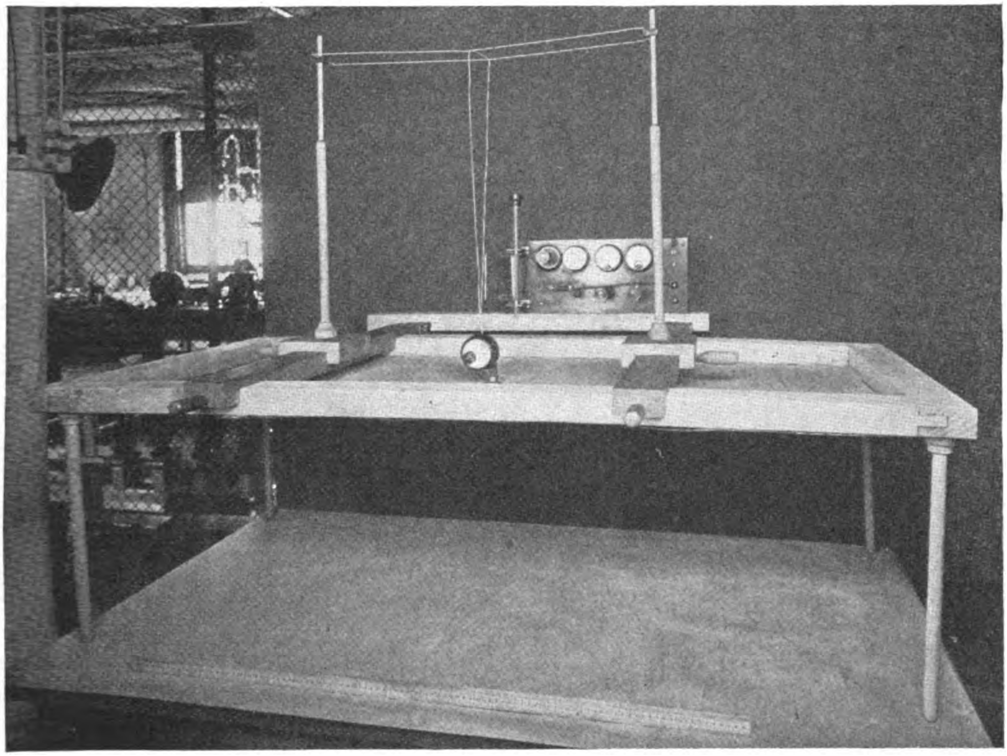
*The lecture was reported in the London and the New York newspapers of November 17, 1925. A portion of it is summarized in "Hypothesis about Push or Contact Force," by Sir Oliver Lodge, *Nature* (London), vol. 116, pages 869-871 (December 12, 1925).



ANOTHER SMALL-SCALE ANTENNA MODEL

This photograph shows the model of a T-shape antenna, the drive being from the center. The mathematical equations for the operation of most shapes of antennas are difficult to solve; some are impossible. For such antenna systems a little advance work with models may save much trouble after the antenna is erected.

Under ordinary circumstances the pressure of light is a very tiny force. It required, indeed, the most delicate and laborious physical experiments to prove its existence.‡ Only with very minute particles, like those driven backward in the tails of comets by the sunlight, does the pressure of radiation become sufficient to influence the movements of bodies in our ordinary world. But all this may be very different, Sir Oliver suggests, when we deal with the world of very tiny dimensions close to atoms.

One of the great mysteries of physics is the mystery of what keeps atoms apart. When you push a wheelbarrow, to continue Sir Oliver's striking illustration, the atoms of your hands do not actually touch the atoms of the wheelbarrow handles. If these did really touch they would always thereafter stick together, unless, indeed, they mutually blew up and vanished. The very fact that atoms continue to exist proves that they do not touch each other so closely that the moving electrons inside them interfere with each other.

What keeps them apart? What is it that transfers the pushing force from your hands to the wheelbarrow handles, even while the individual atoms of the two are still relatively far apart? Sir Oliver suggests that it may be the pressure of radiation.

We know very little about the radiation given off by atoms but one fact of which we do feel fairly sure is that radiation, for example the emission of light, is a symptom of atomic trouble. When an electron shifts its position inside an atom, light may be given off. When an atom disrupts, X rays or gamma rays or some other radiation may be given off. It is possible, Sir Oliver thinks, that when two atoms come too close together this near approach initiates some kind of profound change in the internal electron orbits and that this change, in its turn, produces a momentary radiation of light or of some other ether wave which radiation is intense enough to keep the atoms from further approach merely by virtue of the pressure of light.

All of this takes place, of course, in the very tiny spaces in and near the atom. None of it is perceptible to our coarser senses, except as the resultant cumulative effect is made evident in such interactions as the ability of our hand to push successfully against a wheelbarrow. It is curious that we push things only by the aid of light rays but it may easily be true.

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‡For an account of the discovery see: "Why the Sun Makes Possible Long-Distance Wireless," POPULAR RADIO, vol. 1, pages 249-255 (August, 1922).

New Tests on Amplifiers

Careful scientific tests of the exact performance of radio instruments are so rare that each new piece of work is of importance. One has just appeared as a product of the program of the Radio Research Board, in Great Britain, carried out at the National Physical Laboratory.* Methods have been developed for the testing of the amplification and input impedance of audio-frequency and radio-frequency amplifiers, employing vacuum tubes. A few preliminary tests have been made, also, on the causes and occurrence of distortion in audio-frequency amplifiers. All radio experimenters interested in precise testing methods should consult the paper.

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*"The Performance of Amplifiers," by H. A. Thomas. Paper delivered before the Institution of Electrical Engineers, London, December 2, 1925. The paper will appear in full in the *Proceedings* of that Institution.

The Wind of Ether Past Our Earth

The American Association for the Advancement of Science, an organization comprising the majority of the active research workers of the United States, holds an annual meeting in the week of Christmas and New Year's. For the past three years an anonymous friend of the Association has provided a prize of one thousand dollars, to be awarded for the most important contribution presented before the annual meeting. This year the meeting was held at Kansas City, Missouri, and the annual prize was awarded for a paper which has great interest for the radio public.

The paper was by Professor Dayton C. Miller, of the Case School of Applied Science, at Cleveland, Ohio. Its subject was the complete report of Professor Miller's important and surprising experiments on the actual detection of the ether by physical means.*

These experiments are based, it will be remembered, on the idea that if the ether is a real thing there must be a vast wind of ether blowing through and past our earth as it swings along through space. Imagine an airplane flying through the air. As everyone who has been in an airplane knows, there is a wind of tremendous force blowing past the airplane so long as it is in flight. There is no difficulty in detecting this. Indeed, the existence of this wind constitutes one of the most uncomfortable features of flying.

As soon as the physicists had formulated any idea of the ether at all it occurred to them that there ought to be a similar wind of ether past the moving earth. We would not detect it, they agreed, as the ether probably permeates all material things, including our bodies. It would blow right through us, as the wind blows through a fence of chicken wire. But it ought to be possible, scientists agreed, to detect this wind of ether by physical experiments. Many such experiments were tried. All of them failed, including the famous Michelson-Morley experiment which is one of the chief foundations of the Einstein theory of relativity. The failure of these ether-wind experiments is one of the main reasons why a fraction of the scientists have followed such men as Steinmetz in the conclusion that the ether is an illusion and does not exist at all.

Professor Miller was never of this group. He has persisted in experimental efforts to detect the ether wind. At last, after nearly forty years of work, he believes that he has succeeded. In barest outline, his method involves the measurement of the speed of light in different directions. Light travels in the ether (if there is any ether) and the speed of light ought to be affected by the speed of the ether itself, relative to the observer. If a wind of ether is blowing past the observing station, the speed of light across this wind ought to be a little different from its speeds with or against the wind.

Professor Miller's experiments have been carried out on Mount Wilson, in California, where the great astronomical observatory is located. A variation of the speed of light has been found, just as was predicted. The amount of this variation corresponds, Professor Miller reports, with the position of the earth in its orbit; that is, with its direction of motion relative to the direction of the supposed ether wind of space. All of the data, including over one hundred thousand observations, agree with the hypothesis that there actually is an ether wind blowing past the top of Mount Wilson where the tests were made.

The fact that this wind was not detected by the earlier experiments, made close to sea level, is probably due, Professor Miller believes, to the fact that the part of the ether close to the earth is more or less dragged along with the earth as it moves. Think again of the flying airplane. Inside the structure of this machine there is little or no perceptible wind. The air there is dragged with the plane. Close to the outside of the plane the wind is perceptible but relatively weak. This air is partially dragged with the plane. You must reach out a foot or two from the fusilage before you feel the full strength of the wind that is actually blowing past.

It is just so, Professor Miller thinks, with the earth. Inside the earth the ether is largely dragged along with it. Close to the surface the drag is still considerable. One must climb a fairly high mountain before the wind of ether becomes fast enough, relative to the earth, to be detected by physical apparatus which we know how to build.

From Professor Miller's figures it has been possible, also, to calculate the speed and direction of the motion of our whole solar system relative to the ether. Again the analogy of the airplane will help to make this clear. Suppose that there is no wind, really, so that the wind which the aviator perceives comes entirely from the motion of his airplane. Suppose, further, that the aviator cannot see the ground or determine in any other way the nature of his motion through space. But grant him a set of wind-measuring instruments which tell him the amount and direction of his movement through the air. Then, by the simple device of circling about a little and reading his wind instruments, he can

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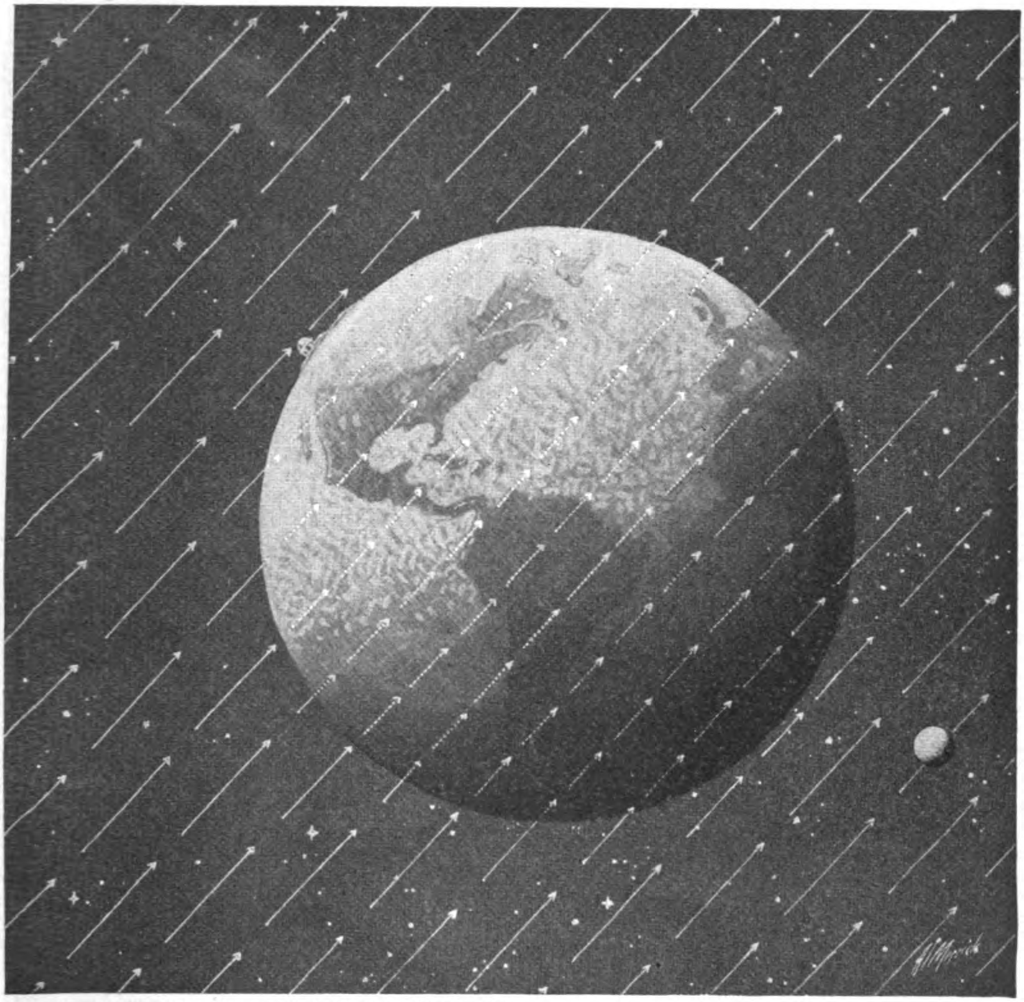
*Professor Miller's preliminary report of these experiments has already been noted in this Department, "Two Important Experiments on the Ether and Relativity," Popular Radio for September, 1925, pages 286-287.



From a drawing made for POPULAR RADIO by Arthur T. Merrick

OUR EARTH AND ITS WIND OF ETHER

If space is filled with ether, as many scientists still believe, the motion of the earth and of the solar system must create a great wind of ether blowing past our globe. Professor Miller believes that he has detected this "etheric wind," as is described on the preceding page. Inside the earth and close to its surface the wind is believed to be less fast, the ether being dragged along, partially, with the earth.

determine how fast and in what direction he is moving relative to the air stream.

Professor Miller has done this for the earth. The movement of the earth in its orbit provides the necessary circling. The ether-wind measurements provide the rest of the data. The conclusion is that our entire solar system is flying through the ether at the tremendous speed of 120 miles a second in the direction of the constellation Draconis. Or, what is the same thing, the ether wind is blowing past our system with this speed and in the reverse direction.

If these results of Professor Miller stand the test of repetition and criticism they will constitute, it is safe to say, the most important piece of physical work since the discovery of radioactivity. They amount to a proof that the ether is real. Our theories of radio waves, of light, of gravitation and of most other physical fundamentals must take this fact into account. We must search for the nature of the ether. Is it composed of tiny flying particles? Is it a continuous medium, like a jelly? Does the electron consist of condensed ether or is it a vacuum in the ether? We will no longer be able to evade these problems by the assumption that the ether is merely a device for thinking, without actual physical existence.

As yet, not all the physicists agree with Professor Miller. They suspect that some error may have crept, unnoticed, into his observations. Only one thing will determine this—the independent repetition of the experiments. It is to be hoped that this will be undertaken immediately by competent experts. Meanwhile, the award of the Association's prize to Professor Miller is an indication that the Committee of Award, which included Professor K. T. Compton, one of our most competent physicists, considers the new experiments as worthy of the utmost respect.

More Experiments with Oscillating Crystals

The crystal oscillators invented last year by the Russian radio engineer, Mr. O. V. Lossev,* have continued to attract the attention of European investigators. It is reported that circuits based on this phenomenon are becoming popular in Russia† and three British investigators have recently published the results of tests with similar hook-ups.§ One of these British investigators, Captain H. J. Round, is so well-known as a competent radio engineer that his results have unusual interest.

It is quite possible, the Captain reports, to maintain oscillations in a circuit containing a crystal of zincite and a source of electric energy, the contact of the zincite and the cat-whisker serving as the generator of the oscillations. However, such oscillators are instable and delicate and sensitive points on the zincite crystal are hard to find, much harder than sensitive points on the ordinary galena crystals used for reception. Pure, crystalline zinc oxide (zincite is the impure zinc oxide found in nature) is even better than natural zincite. The conclusion implied by Captain Round's results is that the Lossev oscillators do not offer, at present, any advantage over the familiar tube oscillators, although they may be worth the attention of experimenters.

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*See "The New Crystal Oscillators," Popular Radio for November, 1924, page 507.

†"The Oscillating Crystal," by C. Nicolaieff. *Popular Wireless* (London), vol. 7, pages 45-46 (September 5, 1925).

§"New Facts About Oscillating Crystals," by H. J. Round and N. M. Rust. *The Wireless World* (London), vol. 17, pages 217-218 (August 19, 1925). "Practical Crystal Oscillator," by L. L. Barnes. *The Wireless World* (London), vol. 17, pages 275-279 and 331-334 (September 2 and 9, 1925).

Do Millikan Rays from Spiral Nebulas Cause Air Ions?

That rays of the new ultra-short variety recently discovered by Professor Millikan* may originate in spiral nebulas billions of miles away in space and that these rays may be responsible, in large part at least, for the phenomena of our Heaviside Layer are the suggestions offered in a recently published letter by Dr. J. H. Jeans, the distinguished British astronomer and physicist.‡

The source of the Millikan rays is likely to be, Dr. Jeans agrees, some profound atomic transformation such, for example, as the union and resultant annihilation of an electron with a positive nucleus or proton. It has long been suspected by the astronomers that this actually takes place in the interiors of the hotter stars, possibly of all stars, and that it is responsible in part at least for the supply of energy which the stellar suns pour out so lavishly into space. In the case of an ordinary star, Dr. Jeans points out, the very high-frequency rays detected by Dr. Millikan could not escape from the star in any quantity, even if they were generated within it. The matter of the star itself would be opaque to them. The only radiation which escapes is that originating near the surface of the star. This constitutes ordinary starlight.

"On the other hand," Dr. Jeans writes, "there are astronomical bodies which are transparent to ordinary ligh[illegible]d probably also to high-frequency radiation. The most obvious examples are the irregular nebulas, such as the Orion nebula and the shells of the planetary nebulas, but the most important to cosmical physics are the spiral nebulas. * * * These nebulas must be almost completely transparent to newly generated radiation, so that practically the whole of the radiation they generate will escape into space without any change of wavelength. Space must be filled with such radiation, and its penetration into our atmosphere would seem to provide a natural explanation of the highly-penetrating radiation recently investigated by Millikan."

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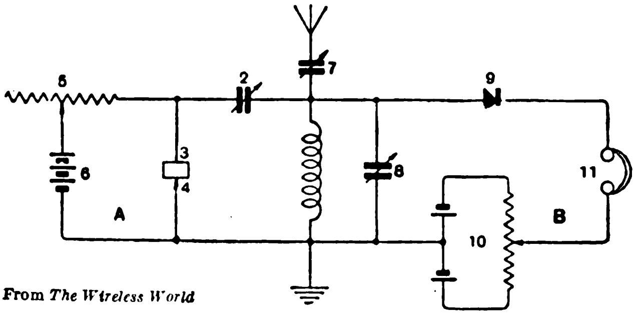
*The discovery of these rays by Dr. Millikan was described in this Department last month, Popular Radio for February, 1926, pages 162-163.

‡"Highly-Penetrating Radiation and Cosmical Physics," by J. H. Jeans. *Nature* (London), vol. 166, page 861 (December 12, 1925).



From *The Wireless World*

CAPTAIN ROUND'S CIRCUIT FOR CRYSTAL AMPLIFICATION

Circuit B is an ordinary crystal detector one. The amplifying circuit is marked A and contains the zincite oscillating crystal 3-4, *a* .0002 *microfarad condenser* (*marked* 2), *a resistance variable in small steps up to 12,000 ohms and a battery of from 30 to 40 volts. The antenna circuit is tuned by the two low-loss condensers marked 7 and 8.*

The University of Chicago

PERHAPS THIS IS A SOURCE OF MILLIKAN RAYS

Diffuse, cloud-like nebulas are suggested, together with the more familiar spiral nebulas as possible sources of the newly-discovered very short rays from space. The two cloud nebulas shown here were photographed by Professor Barnard in the constellation of Cygnus, the Swan. The streak is the trail of a meteor which happened to cross the sky while the exposure was being made.

Calculations of the probable rate of generation of the Millikan radiation in the spiral nebulas and the probable intensity of such radiation reaching the earth agree reasonably well, Dr. Jeans goes on to say, with the observed facts, both the facts recently disclosed by Dr. Millikan and the facts of ionization in the earth's atmosphere.

It is these latter facts which are especially important for radio theory. The action of the ultra-short rays on matter is extremely severe. Atoms are disrupted; electrons are shot out at speeds approaching the speed of light. Exposure of living creatures to intense beams of the Millikan rays for a few seconds would probably result in immediate death. The atoms of the air at high levels above the earth's surface are so exposed to these ultra-short rays arriving from space. Many of these atoms will be ionized; ionization consisting, you remember, in the ejection of one or more electrons from the atom so that the atom itself is left with a positive charge.

This production of negative charges (the ejected electrons) and of positive charges by ionization is what creates, we believe, the Heaviside region of the upper air which region is so important in modern theories of long-distance radio transmission.* If Dr. Jeans is right in his suggestions it may well be that transatlantic radio is possible at all only because of atomic explosions which create ultra-short radiation in vast spiral nebulas more than a hundred thousand light-years away, for that is now the astronomer's estimate of the usual distance of such objects.

Seldom has science presented us with a more vivid conception of the grandure of the universe.

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*For an account of the effects of air ionization on radio transmission see: "How the Air Affects Radio," POPULAR RADIO for September, 1925, pages 199-206, and "How Earth Magnetism Affects Radio Waves," by H. W. Nichols and J. C. Schelleng, POPULAR RADIO for October, 1925, pages 309-316.

Kadel & Herbert

A PRINCE PERFORMS BEFORE "MIKE"

Between the motion picture that brings the royal presences before the eyes of their subjects, and the radio which brings the royal voices into their subjects' ears, it is becoming more and more necessary for kings and princes to play their parts by acquiring both the presence and the voices of skilled actors. Prince Wilhelm of Sweden is here shown broadcasting some of his own poems.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

A Year's Supply of Holiday Hymns

UNLESS you are a great body for Christmas carols (no, we're not exactly crazy about them) you probably got enough of them during the recent season to carry you well into the New Year. Since Xmas hymns and the like take a position near the end of our personal scale of entertainment, we took on enough carol material during the recent high tide to last us way, way into 1929. If it should happen that not a single broadcaster should use any Xmas song stuff during the week of December 25, 1926 (that's a highly speculative thought, isn't it?) our present supply would still be fresh and crisp. That's how the big Xmas programs of the broadcasters scored up here.

We have it from a pretty reliable source (the big throat lozenge people tipped us off) that thousands and thousands of members of quartets spent the entire month of January repairing the damage that 4,562 renditions of "Silent Night" had done to their voices. The records held by "At Dawning" and "By the Waters of Minnetonka" were easily broken and our statistical department is now busy re-arranging its records. According to present figures, "Silent Night" tops the list, with "At Dawning" second. Vincent Lopez is also reported making a fine showing with "Wildflower." We already know where a little Lopez money may be had.

* * *

A Group of Real Creative Radio Artists

IF WE were going to spend five thousand dollars a night on the radio, seeking out the haughty *virtuosi* of the musical world would be one of the very last things that we should do. We are of the opinion that a radio show can be given a full five-quart sound by the use of many other tricks.

If we were asked (probably we never shall be asked) to mention the organization making the greatest contribution to radio theatricals we should immediately put down the Eveready artists. Here is an intelligent effort to improve the art. Since its very first program, the Eveready organization has attempted to pile up new experience and it is responsible for more new effects and schemes than a Hotel Commodore full of studio impresarios.

Will Radio Have a Sex Problem?

Nowaday our Broadway shows are not complete unless some wild-eyed butter and egg man is chasing a Mrs. Babbitt around her Louis XVth bedroom. The sex garbage of every court procedure is dramatized with Howitzer headlines in our newspapers and our movies do little more than depict the loose sex ethics of what is to our directors the Hispano-Suiza stratum of society. The sex language in our novels is as plain as the story of Little Red Riding Hood and characters are incessantly calling themselves or other people dirty names.

With all of this odoriferous stuff going down the chute to public consumption, we should feel pretty happy in the thought that radio is still a virgin source of entertainment, free from the Hearst-McFadden-Woods-De Mille notion of heavy appeal. If radio goes sex, this country will in ten years make the Roman debauchery look like a sorority dance. A few stations have at times been a little "fresh" but in general the record of radio has been delightfully clean and free from anything with a pink appearance.

* * *

A Novel in Fifteen Minutes by Radio

That wholly ingratiating litterateur, Cosmo Hamilton, believes that we are approaching the day when novelists will compress their plots into a fifteen-minute volume for radio presentation.

Mr. Hamilton, it seems, has decided that the age of reading has passed and that this lazy human race will in the near future want its reading matter poured into its ears in fifteen-minute doses. Mr. Hamilton recently tried the idea from WJZ with a literary minuet he called "Sons and Mothers." Our Intelligence Department has not as yet had the time necessary to fully investigate the results of this pioneer move but in the absence of this material we are going to take a chance in saying that the thing came pretty close to being a flop, even though Mr. Hamilton did succeed in obtaining a front page story in the *New York Times*. It has been whispered around that Mr. Hamilton was more interested in getting on the front page of the *Times* than he was in convincing the world that ninety-thousand page novels would soon go the way of celluloid collars and Mah Jongg.

* * *

Why Thousand-dollar-a-night Voices Sound That Way

Those who have religiously followed these little diamond studded paragraphs have probably noticed our poignant criticism concerning the appearance of so many musically inclined Joneses and Smiths on the air. Here again the virus of doubt has entered our system and we are about (not quite, but *about*) ready to admit that Sadie Jones who comes to the studio with a Ford and galoshes impresses us almost as much as her silver-slippered sister who arrives with her limousine, photographer and publicity man. We have asked ourselves frankly and honestly if we really can notice anything existing between the voice of Sadie and Gabriella that could be called a whale of a difference. We confess publicly and unashamed that, as far as the radio is concerned at least, the heavy efforts of practically all of Sadie's expensive sisters entirely elude our sense of musical appreciation. Perhaps we can save a little of our grace by admitting that we do detect a difference in technique, but the question of voice quality finds us sitting on the old board fence. This will probably be a big disappointment to those who have thought right

© Goldensky Studios

RE-SOUNDING THE TOCSIN OF FREEDOM

Perhaps the fear that Americans, deluged with prohibition laws, censorship and other restrictive legislation, might forget the spirit of liberty that fired their forefathers inspired station WIP to broadcast the ringing of this liberty bell on New Year's Eve. Mrs. Freeland W. Kendrick, the wife of the mayor of Philadelphia, sounded its tones—gently, with a tiny rubber mallet.

along that we were a musical connoisseur with highfalutin ideas.

When we came to this big decision, we were thinking of Johnny Fish in Penn Yan, N. Y. Johnny built his own "two tuber" from the Woolworth-Kresge supply base and he has something which he thinks in his Penn-Yan way is pretty nice. And let us tell you that you can see the aerials of thousands of Johnny's counterparts from the windows of the Sixth and Ninth Avenue "L's." On Johnny's radio set a voice is a voice and hardly that. The quality of a voice, in Johnny's ears depends solely upon the label you put on it. If you say it is Sadie, it is "punk" but if you say it is Gabriella, it is "great"—largely because the name sounds expensive. Let the announcer say that such-and-such a voice is one of the accessories of the Metropolitan Opera House and all of the Johnnies in the country will sit enthralled before their horns.

What we have been trying to tell you, Dear Reader, in case you have been unable to find out, is that 95 out of every one hundred radios reproduce badly. So badly in fact, that any registration of real art in singing is usually impossible. Of course, there is some solace in the knowledge that we have so many goofs in this country who fall for foreign-sounding names and Rhinestone headbands.

* * *

The Problem of Announcers Again

Just as this Department was beginning to feel that it had the announcing situation well fixed and that all of our little big men in the studios knew exactly what we thought of them, a few high school girls sent Mr. Norman Brokenshire (WJZ) some silly mash notes, and now we have another very bad case on our hands.

Mr. Brokenshire has never made what you could call a staggering hit with us for we have felt that this young man was always pretty sure that it was Mr. Brokenshire speaking and that Mr. Brokenshire was a very erudite person. If we sat down to write a column that read like Mr. Brokenshire talks we should sooner or later expect to be exposed.

We don't know what there is about the radio that makes announcers feel so important and makes them want to talk like millionaire graduates of Oxford. Mash-notes is about the only solution that we have. The cheapest and saltiest ham that ever played the lead in that stirring drama, "Way Down East," probably felt the same way when the high-school girls of Little Falls wrote to tell him what a perfectly wonderful guy he was.

It is not in the heart of this department to write to Mr. Brokenshire to tell that we know that he is not as ritzy or as blasé as he would try to have us believe.

We cannot close this exposé without registering another protest. We wish Mr. Brokenshire would stop trying to be funny. Sometime ago this young man asked the orchestra for which he was announcing to play "A Cup of Coffee, A Sandwich and You." When he turned to "the boys" and asked them to "coffee up, coffee up, now," this sour old thing rolled off an oath that was nothing short of scandalous.

That shows what kind of a listener to good humor we are.

Underwood & Underwood

IT'S NOT ALWAYS WORK IN THE WORKHOUSE

Radio furnishes entertainment for the inmates of the Southwark Workhouse in England. An old phonograph horn has been pressed into service as a loudspeaker.

Pacific & Atlantic

SPREADING A POLICE ALARM THROUGH THE ETHER

When this set of bells (which is tuned to selected frequencies) is rung into the microphone of station WHO of Des Moines, Iowa, it causes a white light to flash in specially constructed receivers placed in all police stations. In this way a police alarm may be spread and descriptions of criminals broadcast the moment a crime is reported. The whole State of Iowa is covered by this system.

A Silent Night in New York?

WHEN the news that the Chicago listeners were out on some sort of a strike came, (that does sound foolish, doesn't it) we thought that the sloppy broadcasting in the Chicago district was responsible for it. We confess that we cannot quite apply the same theory to a communication now laying on our desk signed by some mysterious "Citizens Radio Committee" and announcing the beginning of a movement to bring about a silent night in Greater New York. Like the Chicago affair, the movement is supposed to represent the wailing of thousands and thousands of injured listeners who, caring not a *durn* about what the majority may desire, set out to inveigle the broadcasters into the belief that nothing but a silent night will save the radio business from positive ruin. As in the case of prohibition and a dozen other evils growing from like sources, it is the noisy and cranky minority that carries its point.

We publish herewith, part of the letter received from this "vast" and peeved body (which appears suspiciously like the efforts of a single person floating under a self-appointed Executive-Chairmanship):

"Dear Sir:

"Like every American institution, the broadcasting station is a product of public opinion, a reflection of popular desire. A broadcasting station, if it is to function properly and perform a real service, must supply what its patrons desire and in a satisfactory manner, not what its sponsors believe is proper. The only barometer of the public's opinion is the verdict of the listener.

"In the silent night controversy the real reasons, purposes and benefits are:

"First of all, the listeners; they are the ones who, through the purchase of their sets and parts, made the industry what it is today. They have spent millions of dollars for apparatus which has given the industry the wherewithal to develop the science. . .

"These listeners are spending thousands of dollars in telegrams, phone calls and letters to encourage the station and make for the betterment of radio, and every fair-minded station realizes that it must please the listeners if it is to have a large regular happy and satisfied audience.

"There are many other reasons why the listeners' wishes should be satisfied. They certainly have their rights which should be respected. Silent night is not being requested for the express purpose of eliminating interference of one station with another; that is a matter for the United States Government, which is ably handling the matter.

"It is not a matter that requires technical tests, as some have suggested, nor is it a matter of teaching the fans how to tune their sets as some others have suggested. That is being taken care of and the fans are rapidly learning the art.

"When several stations in a certain area, being within the magnetic field of each other, are broadcasting at the same time, a general interference is set up, which prevents a great many in that area from cutting through for DX stations with any kind of satisfactory program. If the wave band of any one of these stations is close to that of a DX station, then it is almost impossible for many to bring in the distant stations, and if they do get it, reception is marred or spoiled. Therefore, those without 'supers' should be considered.

"The solution of the problem seems to hinge on the selfishness of different factions among the listeners in and the broadcasting stations. Those with 'super' sets receive out-of-town stations seven nights a week, while those owning less efficient sets merely ask for one night, Friday, after 7 P. M.

"I have spoken to several owners of broadcasting stations with regard to advertising programs. I do not want them to misunderstand my statements. Every broadcasting station is an advertising medium and it makes no difference to the listener if everything they broadcast is paid for, for they realize that no one is going to invest the money necessary to install a station and operate it just for the fun of it or the pleasure the public will get out of it. It would be unreasonable to think this. It is a business proposition with the stations, and we hope everyone will be able to make a great profit on the investment.

"I want it understood that the Citizens' Radio Committee, sponsoring this drive for a silent night, is in no way antagonistic to the broadcasting stations. It has on every occasion offered its cooperation and assistance to them in every way possible, for that is the very purport of its platform. Some stations have realized this and expressed their thanks to us.

"The listeners do not want to be unfair or unreasonable. All they ask is the co-operation of the stations, to consider the privileges they are entitled to.

"The majority must govern, selfishness cannot be considered.

"Respectfully, and 73s
"JOEL J. MICHAELS,
"Executive Chairman."

A radio receiver becomes a mere toy in the hands of a certain class of listeners. They care nothing about the merit of the local performances; they are animated by some sort of a kid passion to reach out and see how many stations they can log. In the average case they manage to catch nothing but the call letters but, in their kidlike enthusiasm they call that radio reception. Ask an engineer who knows his business (and be mighty careful whom you ask these days) and he will tell you that perfect radio reception is impossible over a distance of 100 miles. He will tell you further that music loses its edge and beauty. It becomes "thin" and the tendency toward distortion in the average receiver is great.

We are that type of body known as a stay-at-home when it comes to radio, for, if we do say it ourselves, we turn a frightfully critical ear toward our cone. Distance means no more to us than the saving of cigar bands or marbles, and yet it may come to pass that the kindergarten class of radio listeners will win out, and we shall have to spend one evening a week at the movies. The plan for the silent night does not sound 100 percent American to us and we believe that we shall turn the entire matter over to the Klu Klux Klan.

It is inconceivable that anyone but a clique of cranks could feel that a silent night in New York would be an ingratiating asset to the radio art. It is odd, isn't it, to see the will of the minority spending its force here and there without regard for consequences and certainly without respect for the rights of the majority. We take it that the little boys who started this movement have not stopped to give a thought to the hundreds of thousands of people outside of New York City, who depend night after night upon the Metropolitan stations for their entertainment. And what would our whimpering laddy-bucks say if they should gain their point (God forbid!) and they go out to search for distances only to find that their boy friends in several other large cities have noised the broadcasting off the air? It is not difficult to see that this long-distance fishing game will defeat itself in time but it seems that it is up to us to prepare an ABC treatment on the subject so that all the members of the Radio Boy Scouts will surely understand.

* * *

What Percentage of Light Music Does a Program Need?

WHEN our publicity boys at the radio studios get hard up for ideas, they sit right down and pound off about four and one half gallons of literary near-beer dealing with the big, vital subject of "Jazz *vs.* Classical Music." These heavy manuscripts usually start out like this:

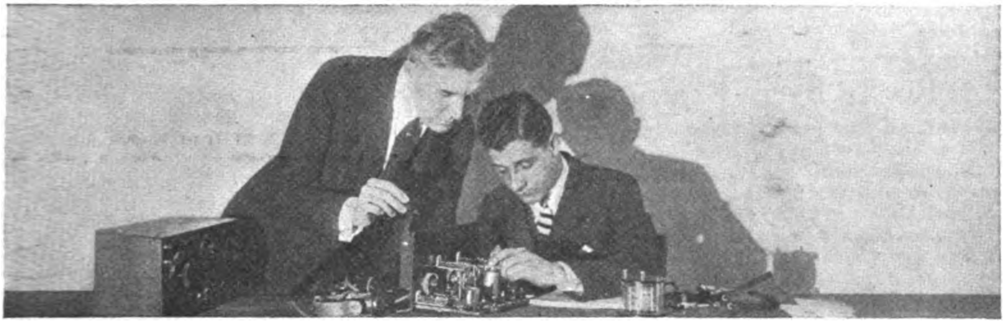
"King Jazz is slipping," or, if the studio happens to be in the jazz market, "Jazz is holding its own with the listeners of the United States."

This and the subject of radio movies can pass the guard of any editor from the *New York Times* to the *Oshkosh Record.*

There was a day, and not long ago, when this department talked nasty about jazz—calling it by some presumably funny name. That just shows how silly and inconsistent you can be if you don't watch yourself all of the time. Here we are just waking up after four years of being Bached, Schuberted, MacDowelled and Wagonered to a point where we are simply as limp as a rag—the music has been so heavy that 98 per cent of our energy has been consumed in digesting it. There has been little left to enjoy save the fact that we have been listening to the masters. When we started out with this business of listening to the masters *via* the air we had no use for Bell-ans charcoal tablets but now, we confess, we are quite worried about our condition.

If it had not been for Mr. Bernie and Mr. Lopez (even with his high "Wildflower" record) we should have had almost a miserable time with the radio. We are in our present licked condition, willing to go on record as saying that the jazzists of this country did a big thing for broadcasting when they prevented it from falling entirely into the hands of our Size 1, Series E musical high-brows in the studios.

After all, this old world wants a little salt with its pepper, a little soda with its liquor, a little sugar with its vinegar and a little calves' liver with its bacon.



IN THE EXPERIMENTER'S LABORATORY

CONDUCTED BY LAURENCE M. COCKADAY

The Raytheon Plate Supply With the Four-circuit Tuner

IT does not seem to be generally understood that the Raytheon Plate Supply Unit (described in the November issue of POPULAR RADIO) can be used with the Four-circuit Receiver with Resistance-coupled Amplifier, which was described in the October, 1924, issue. This combination is entirely practical, as is here explained.

When "B" batteries are used to supply the plate voltage of this receiver, it is necessary to use a separate 22½-volt "B" battery for the detector. This is necessary because the negative side of the detector "B" battery is connected back to the "A" battery through the potentiometer winding in the "Dubl-Wundr." This is the arrangement used for varying the plate voltage on the detector tube, by simply rotating the knob of the potentiometer, thus providing the exact adjustment of the plate voltage for maximum sensitivity. If three 45-volt blocks of "B" battery are used to provide the necessary 135 volts for the amplifier tubes and a tap is taken off at 18 volts for the detector, trouble will result because the negative side of this "B" battery is connected to both the detector "B-" and the amplifier "B-" posts on the receiver. Inside of the receiver these two posts are connected to the slider of the potentiometer (Dubl-Wundr) and to the positive side of the "A" battery respectively. In effect the slider is thus connected to the positive side of the "A" battery It is therefore evident that when this slider is moved toward the negative side of the "A" battery, thus decreasing the resistance between the slider and the negative end of the potentiometer winding, the "A" battery will be short-circuited through this part of the potentiometer resistance. If the slider is moved all the way to the negative side of the resistance winding there will be a direct short-circuit of the "A" battery, or if moved to within a few turns of the negative end, there will be little resistance in the circuit and a sufficiently large current will flow through these few turns to burn them out. In this latter case, of course, the potentiometer will be ruined.

If the negative terminal of the common "B" battery is connected only to the amplifier "B-" terminal of the receiver, and not to the detector "B-" terminal, no advantage will be gained from the potentiometer and the receiver will not have maximum sensitiveness or volume.

For these reasons it is evident that the Raytheon Plate Supply Unit cannot be used to supply both the detector and amplifier of this receiver if its negative terminal is connected to both negative "B" terminals of the receiver. However, when this unit is used there are two ways of getting around this trouble. The first is to use a single 22½-volt "B" battery for the detector as before, but to use the Raytheon Unit for the amplifier voltage. This is perhaps the best plan because it practically eliminates "B" battery worry inasmuch as the current drain on the detector "B" battery is so low that the life of the battery should be in the neighborhood of a year.

If it is desired to dispense with the "B" battery entirely results practically equal to the above may be obtained by connecting the negative terminal of the Raytheon Unit to the amplifier "B-" terminal of the receiver, ***but not to the detector "B-" terminal.*** Then connect the positive detector terminal of the Raytheon Unit to the detector "B+" terminal of the receiver, and the high voltage positive terminal of the unit to the amplifier "B+" terminal of the receiver. As explained above, this makes the potentiometer ineffective but the Bradleyohm variable resistance provided in the Raytheon Unit serves the same purpose as the potentiometer.

The use of a separate "B" battery for the dectector and the Raytheon Unit for the amplifier has the advantage that finer variation of the detector plate voltage can be obtained by means of the potentiometer. There is the added convenience that the potentiometer control knob on the panel of the receiver is more accessible than that of the Bradleyohm. For local reception maximum sensitivity is not necessary and therefore frequent adjustment of the potentiometer is not required but when tuning in distant stations—for the DX fan—the potentiometer provides the better arrangement.

—S. GORDON TAYLOR

Record Every Experiment!

WHILE I was recently examining the Patent Office old records, I noticed that inventions "come in bunches," so to speak. The first patent on a steamboat, for instance, was issued to Robert Fulton in 1809; within a few years many other inventors followed with various improvements and the Patent Office was deluged with applications for steamboat patents. The bicycle craze, which extended over about ten years, resulted in hundreds of bicycle improvement patents being issued during that period. And so the story continued through the new era of telegraph, telephone, automobiles, locknuts, vacuum sweepers and many other inventions.

Today we are in the radio era. Hundreds of applications for patents on radio apparatus are being received every month by the Patent Office. Many of the inventors will be made rich; others will waste much time, considerable money—and will meet with disappointment.

Millions of dollars have been made from simple inventions, so simple in fact that almost every person who afterward saw them wondered why they also had not thought of the same things.

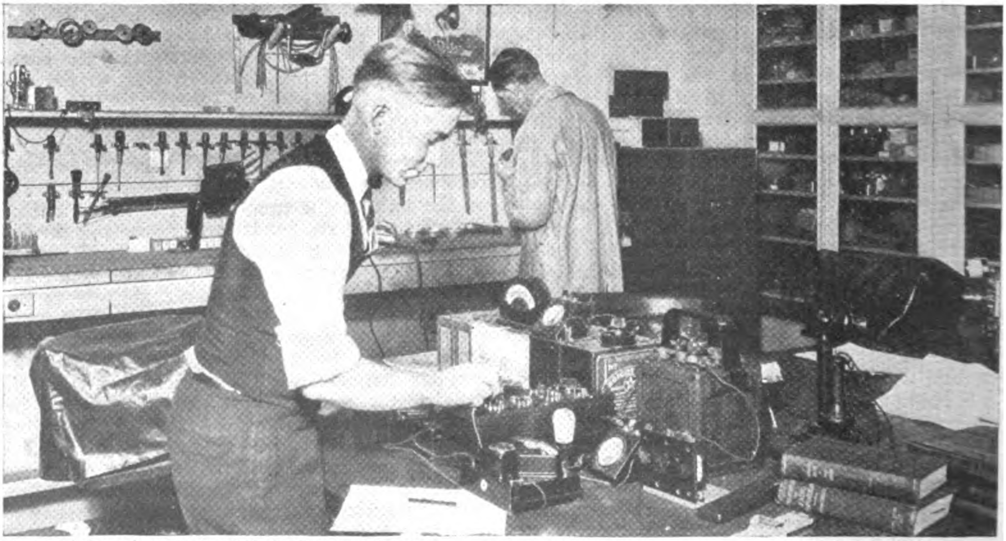
The radio industry, however, presents a different situation from many of the past subdivisions of new discoveries. No man can tell absolutely whether or not a great majority of electrical experiments will prove successful, except by actual test. In other words an inventor of radio electrical improvements must necessarily carry on numerous experiments, never knowing whether the results will prove good or bad.

All of us who have attended technical schools will remember the tedious and apparently foolish and unnecessary requirement of keeping an accurate and detailed laboratory record, irrespective of how unimportant the experiments appeared to be. It is true that considerable time is consumed in doing this, but every experimenter should establish an iron-clad rule, never to proceed with an experiment, regardless of its apparent simplicity, without first preparing a neat note book, with the page correctly dated, and make the required sketches and the notes of the accomplishments as the results are affected.

The reason this should be done is that practically all valuable patents are at one time or other adjudicated in the courts. In other words, the strength of the patent will be thoroughly tested by persons or firms who want to manufacture the product without paying a license fee. Litigation is almost inevitable. Moreover, some individual may infringe the patent and it may be necessary for the inventor to prove priority rights. In either case the note book evidence is very important, and has been known to have sufficient weight to win a suit.

Only recently a great battle between Armstrong and De Forest was decided in one of our higher courts. Previously a lower court decided that Armstrong was the inventor of the regenerative circuit, but the last decision was rendered in favor of De Forest, and as the records of the trial show, his notebook was an important exhibit. In it was a sketch of the circuit, together with a written description of the obtained results. This page also bore the date of the experiment.

Many persons are carrying on experiments daily with various radio circuits and numerous applications for patents on improvements of radio apparatus are being filed. It therefore



From a photograph made especially for POPULAR RADIO

HOW THE PRACTICAL EXPERIMENTER DOES HIS WORK

Laboratory work which deals with new developments would never have any practical result if the data which are gained were not carefully recorded. The engineer shown in this illustration is determining tube characteristics and recording his results in the form of tables which will be made into curves for future reference.

behooves every inventor to establish his date of priority.

The great battle between Dr. Bell and Elisha Gray, in the celebrated telephone patent case, was decided in favor of Dr. Bell, even though both of these men filed their papers in the Patent Office a few hours apart on the same day. But Dr. Bell satisfactorily proved to the Court that he was the real inventor. That is the only reason he was awarded the patent. That decision meant $40,000,000 to him. And it is not an overestimate of the amount of money which he received from royalties on the patent.

As yet the radio industry is in its infancy. The future holds in store many wonderful and presently inconceivable improvements in radio apparatus. Experiments will prove profitable to many. Practically everything that is known of radio today was discovered by an apparently unimportant experiment. Therefore any experimenter who owns a radio set, whether it is a small crystal set or a complicated and expensive heterodyne, has as good a chance of making a valuable discovery as those who already have done so. So he should keep a detailed record of every change in the wiring and arrangement of the circuits, so that if new and beneficial results are accomplished it will be no trouble to reperform the experiment. And above all, a complete record is on file for future reference, if it is needed to assist in establishing the inventor's rights against some other inventor who may have successfully performed the same result within a short period afterward.

—Leo T. Parker

The 8-tube Reflex Superheterodyne Receiver

In cases where it is desired to use this receiver to reproduce broadcasting with great volume, as in a hall or large room, the use of the new power tube UX-112 in the last stage of audio amplification will give rather surprising results. Such a tube is better able to handle the large amount of energy put into the last tube in this receiver, than is the UV-201-a type.

When using the UX-112 for this purpose it is not necessary to make any change in the wiring of the circuit. Simply remove the UV-201-a tube and replace it with the UX-112. A separate rheostat is not needed. It is a good plan, however, to connect a "C" battery in the grid return of this tube. This is easily accomplished by breaking the connection from the grid leak 06 (see diagram in descriptive article on this receiver in Popular Radio for January, 1925) to the "A" battery circuit, and inserting a 4½ volt "C" battery. The positive terminal of the "C" battery is connected to the -A circuit and the negative terminal to the grid leak.

In addition to better and louder reproduction of signals, this arrangement will eliminate the howl which is discussed in the following paragraphs, without the necessity for using the variable grid leak.

When the "B" batteries used with this receiver start to run down a howl frequently develops if the loudspeaker is placed close to the receiver. Or this may even be true in some cases with fresh "B" batteries. In the latter case the trouble lies in a so-called "microphonic" tube in either the detector or one of the audio-amplifier sockets, or perhaps from the failure to use a vibrationless socket for the detector tube.

When changing tubes around does not eliminate the howl, it is fair to assume that the howl is the result of partly run down "B" batteries. Sometimes the howl has been known to start when the batteries had dropped to about 39 volts, whereas the useful life of the battery should be until the voltage drops to about 34 volts per 45-volt block.

The remedy for the howl is to connect a variable grid leak such as the Bradleyleak across the resistance 06 (see illustrations of constructional article in the January, 1925, issue of Popular Radio) which is the grid leak of the last audio amplifier tube. With the set in operation, this variable leak is adjusted to a point where the howl stops and the signals are clear and undistorted.

This adjustment will cut the volume slightly, but under ordinary conditions the volume produced by this receiver is able to stand such a reduction.

Incidentally, this variable leak provides an excellent volume control because by decreasing the resistance of the leak sufficiently the signal strength can be cut down almost to a whisper.

—S. Gordon Taylor

Three Hundred Million Miles an Hour

This is not the speed of any rifle bullet or even of a runaway comet. Such things are far slower. Yet this astounding speed exists. It exists right here on earth. It is the speed of some of the tiny electrons inside the atoms of matter. These marvelous speeds of atomic rotation, transcending all ordinary human experience, will be described in the next issue of Popular Radio *by Dr. E. E. Free.*

LISTENING IN

Practical *pointers from experimenters and broadcast listeners. What helpful hints can* YOU *offer to your fellow fan? Readers are invited to address their letters to the editor of this Department.*

Conducted By Lloyd Jacquet

How I Made a Low-Loss Terminal

I **made** a low-loss terminal for my newest Cockaday receiver from material on hand in the shop. (See Figure 1.)

A piece of glass rod, such as is used in bathrooms provided the body of the job, while brass strips supplied the means of supporting the clips to which connections were made and soldered.

Heavy brass brackets fitted around the ends of the rod provided the supports. These were drilled, so that the entire assembly could be screwed on to the board.

As many of the brass strips as there were terminals may be used. Small nuts and bolts serve to tighten up on them so that they will not work loose upon the glass rod.

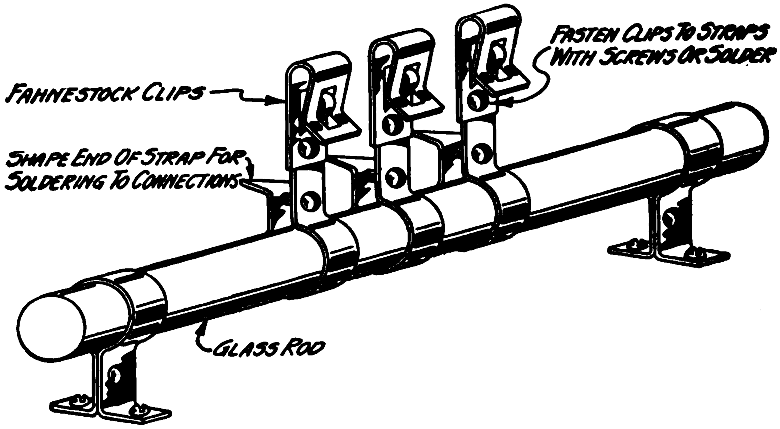
Although I used Fahnstock clips for the connectors, the wires may easily be soldered directly on to the strips. This terminal is neat, and because glass is used, the insulation is practically perfect.

—E. M **Backman**, *Sharon, Pa.*

* * *

A Station Card-Index

Stations have changed their locations and data so often, that their wavelengths have been a subject of periodical correction in my call book. This document became so inaccurate with time, that I decided to install a semi-



A DIAGRAM OF A SIMPLE LOW-LOSS TERMINAL

Figure 1: *The low-loss terminal which is illustrated here may be cheaply assembled from a glass rod and a few brass strips. The insulation is practically perfect.*

permanent recording system which could be easily kept up to date.

This led me to devise the card system, which was placed in a filing box. This gave me new information about stations at an instant's notice, and provided me with an easily corrected record.

I had several hundred cards run off by a printer, containing the major heads. Ordinary small filing cards were used and all the information that the average fan wants—or at least, all I wanted—was carried on them.

I then proceeded to fill in the station call letters and the information that I had at hand regarding them. These I filed alphabetically by call letters, beginning with the "K" series.

At regular intervals, I indicated the alphabetical arrangement, such as KDKA, KFI, WEAF, WOK and so on. A regular small filing cabinet contained the five hundred or so cards required.

—S. Kessler, *New York, N. Y.*

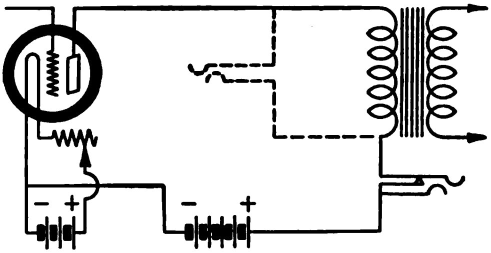
* * *

A Remedy for Soft Tubes

Although soft tubes require somewhat critical "B" battery voltages, I find that I can get good results from an old tube of this type. As I cannot get fine regulation of plate voltage from the "B" battery which I have, I introduce a small non-inductive resistance in the plate circuit of the tube. (See Figure 2.)

This resistance, which need not be more than 100 ohms with a battery voltage of 22.5, is placed in series with the "B" battery. By regulating this resistance, I get the best operating plate voltage, and can leave the filament adjustment without change for the entire evening.

—Paul Barrett, *Baltimore, Md.*



HOW TO CHECK LOUDSPEAKER PERFORMANCE

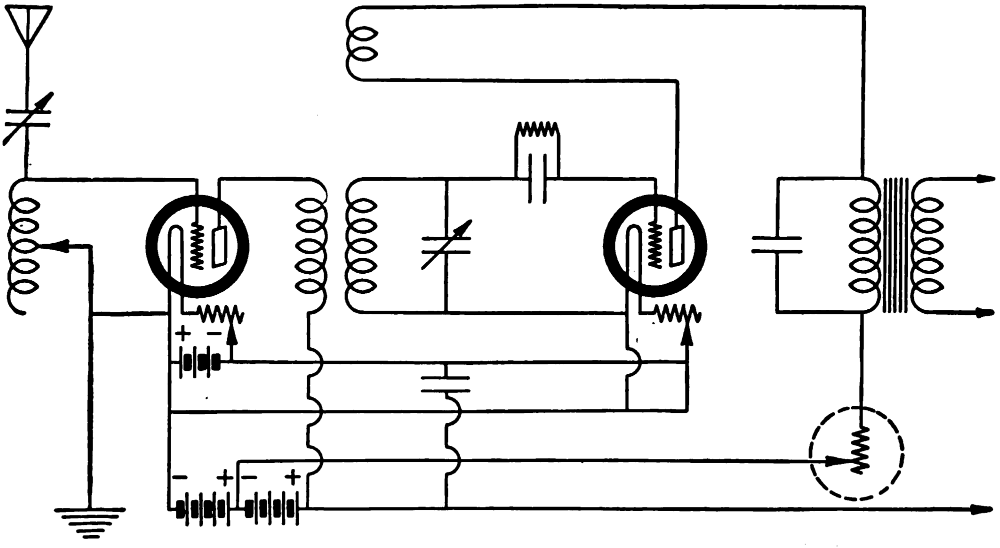
Figure 3: *Either an open circuit jack or a single closed circuit jack may be used to test the various stages from the detector circuit to the loudspeaker. The loudspeaker need not be cut off while the phones are in circuit.*

How I Made My Loudspeaker Perform Properly

It has been a habit for radio fans to tune in with headphones for long distance reception and then, increasing the power, to switch on the loudspeaker. The results were not always as expected.

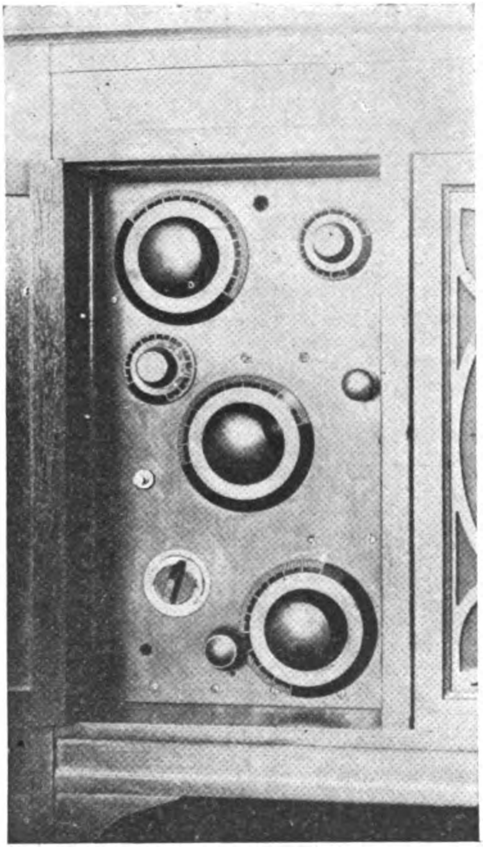
I ran into this idea while looking for trouble in my five-tube receiver. After testing the audio-frequency amplifier, in which I suspected a fault to lie, I found that everything was all right. But it was from the detector that poor results were coming. I inserted a jack in series with the primary winding of the transformer and the "B" battery, as shown in Fig. 3.

This was a closed-circuit jack, and when I inserted the phones I could hear the broadcasting



HOW TO CONTROL THE PLATE VOLTAGE OF A CRITICAL TUBE

Figure 2: *To do this, a small non-inductive resistance is placed in the plate circuit of the tube. This schematic diagram indicates where the insertion should be made.*



THE PANEL OF THE CONSOLE RECEIVER

FIGURE 4: *The diagonal arrangement of the three condenser dials shown here make it possible to obtain maximum spacing of the units.*

which was also reproduced in the loudspeaker at the end of the audio-frequency amplifier. This idea helped me greatly in tuning in with the long distance stations and gave me an absolute check upon my audio amplifier and speaker.

It is not necessary to disturb the wiring of the receiver at all to locate this jack. It occurred to me that an open-circuit jack could be connected across the primary winding, as shown in the diagram. In fact, I have equipped all of my stages with this arrangement, so that I can find any trouble almost instantly.

In one case (the first) the jack will place the headphones in series with the transformer winding, and in the second, the headphones will be in parallel. In either case the loudspeaker may be kept going while the phones are in use.

—IRVING MULLER, *Woodhaven, L. I.*

* * *

How I Built a Radio Set in a Console

ALTHOUGH space is at a premium in the record compartment of the average phonograph, it is possible, nevertheless to build into it a five-tube set. (See Figures 4 and 6.)

Here is how I did it:

I placed the main tuning dials diagonally across the panel, which insured maximum spacing of the tuning units—a great advantage in radio-frequency tuning.

I provided extra lengths of wire so that the entire unit, which is built on the panel, may be pulled out for inspection or repair. The two radio-frequency tubes are mounted on the small base-shelves of their own. The detector and the first audio tube are on the large shelf to the right, and the last audio tube is placed on the baseboard.

Assembly need not be cramped, if proper care is taken in the location of the apparatus beforehand. Of course, it is necessary to study out the effect that the panel layout will have on the balance of the phonograph furniture before anything at all is attempted.

—HUGH G. BERSIE, *Chicago, Ill.*

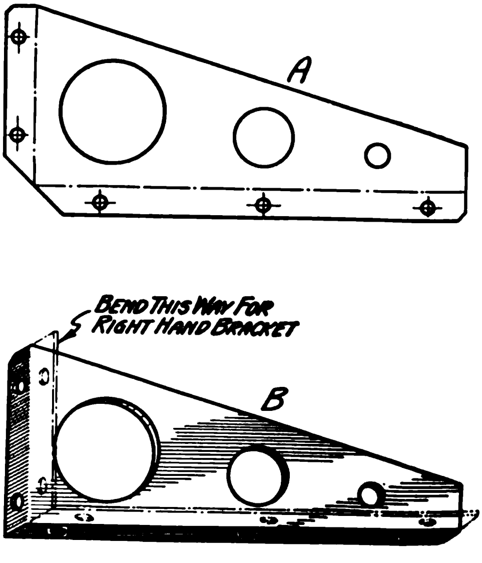
* * *

Home-Made Brackets

I WAS greatly handicapped in the finishing of my McLaughlin Receiver by not being able to secure the necessary brackets which hold the panel at an angle to the wooden base.

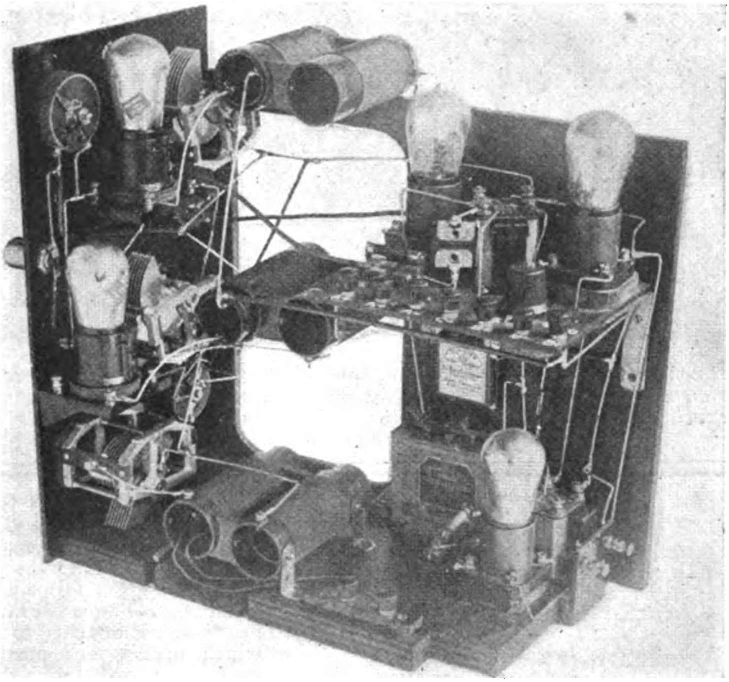
However, it was a pleasant "job" to make a pair which served the purpose and it enhanced the appearance of the set considerably.

I secured a square foot of heavy brass, about one sixteenth of an inch thick. Having drawn the right size bracket specifications on a piece of drawing paper, I cut it out with a sharp pointed knife, making a duplicate. One of these



THE PATTERNS OF THE BRACKETS

FIGURE 5: *"A" is the pattern for the completed bracket. The drawing "B" shows the edges bent for a left-hand bracket. The dotted lines show how the edges are bent for a right-hand bracket.*



A VIEW OF THE INTERIOR OF THE RECEIVER

Figure 6: *This unique arrangement of apparatus was forced by the limited space in the record compartment of the phonograph for which the receiver was designed. The two radio-frequency tubes have been mounted upon small base-shelves supported by the main panel, while a side panel supports much of the remaining apparatus. Extra lengths of wire have been provided so that the panel unit may be pulled out for inspection or for repairs.*

drawings was for the right-hand side, and the other for the left-hand side.

It was easy to locate the two patterns on the brass, and they were outlined with a sharp point on the metal. With a heavy pair of shears, or better yet, a small metal saw, the units were cut out. Then, sections in the shape of holes or triangles were drilled and filed away, as shown in Figure 5.

Sufficient material was left on two sides, which were to be bent over, after drilling. This operation was done with the vice and a wooden mallet.

Cheap, strong and handsome brackets for any use can be built in this way.

—Robert Conway, *New Orleans, La.*

* * *

Hints for Using the Soldering Iron

When the inveterate radio constructor starts on a job, it is usually of the marathon type and he does not leave his shop until the batteries are connected and the tubes inserted in the newest radio acquisition.

The electric soldering iron is generally the tool that suffers in this procedure. It is continuously being heated for a period of two to five hours; and it shows all the effects of hard use when all of the wiring is finally completed.

Not only must the builder watch the iron, turn it off when it is getting too hot, turn it on again before it becomes too cold, but he must tin it, keep it clean and generally devote as much time to keeping it in condition as to the actual soldering itself.

Here is how the problem was solved in my work shop:

I have a line with plug receptacles located at convenient intervals along the working bench. Near the switchbox, which is off to one side, there is a socket into which I placed a 75-watt electric light bulb. This bulb is connected in series with the line.

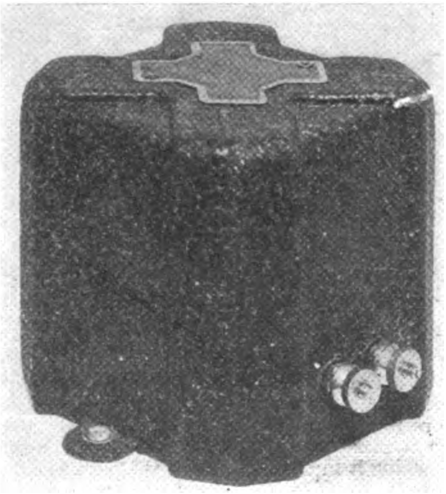
This bulb allows sufficient current to pass through to the electric soldering iron to keep it at just the right temperature. I never have to watch its temperature, and the tinning process does not have to be repeated except occasionally.

Of course, other devices besides the soldering iron may be operated from the plug sockets. My small electric drill also connects to the plug, as well as a small motor which runs a buffer, coil-winder and drilling arrangement. The installation is comparatively inexpensive and its saving in temper alone is worth the trouble. It can be installed by the radio fan builder himself at the cost of very little time and trouble.

—David Lay, *New York, N. Y.*

WHAT'S NEW IN RADIO APPARATUS

THIS *department is conducted by* **POPULAR RADIO LABORATORY** *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*



A NEW TRANSFORMER WITH UNUSUAL CORE DESIGN

Name of instrument: Audio-frequency transformer.

Description: This transformer contains four sections of core which are arranged in a cross-shaped pattern when looking at the transformer from the top. They are really four separate square-shaped cores which almost totally surround the coil windings. The transformer has a high value of primary inductance and is pleasingly efficient over a large band of audio frequencies. It is furnished in a metal case with binding posts brought out for the necessary terminals.

Usage: In an audio-frequency amplifier as an interstage coupling unit.

Outstanding features: Large core area. Improved amplification at the lower frequencies. Neat appearance.

(Further details furnished on request)

A NEW VERNIER KNOB

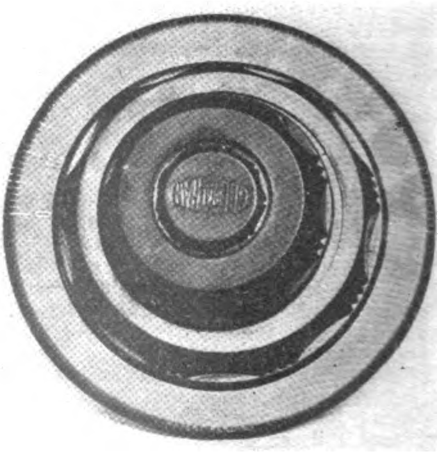
Name of instrument: Knob and dial.

Description: An ingenious application of two ring gears of different ratios in which one of the gears forms a tilting table arrangement. The small inner knob of this instrument is attached to a rotating slider which presses one portion of the top gear enmeshed with the lower gear. Upon revolution of this small knob the difference in the ratios of the two ring gears causes the dial to revolve extremely slowly in accordance with the difference of the number of teeth of the two gears. In this case, a ratio of 100 to 1 is produced.

Usage: With a tuning unit in a set.

Outstanding features: Neat appearance. Extremely smooth vernier action without back-lash. Provides direct gearing as well as vernier gearing.

Maker: *(Further details furnished on request.)*



Apparatus Approved by Popular Radio

This list of apparatus approved by the POPULAR RADIO LABORATORY will be continued as a part of the WHAT'S NEW IN RADIO APPARATUS department until all instruments, parts and complete sets have been included. The listing is alphabetical by manufacturer's name and the installment in this issue includes the letters C through E.

AERIALS

Silver-Tone antenna; Colonial Brass Co.
Tinned "Copperweld" antenna wire; Copperweld Steel Co.
Ducon lamp socket aerial; Dubilier Condenser & Radio Corp.
Lamp socket antenna; Electrad, Inc.
Indooraerial; Electrad, Inc.

AMPLIFIERS

Super amplifier; Daven Radio Corp.

AUDIO-FREQUENCY TRANSFORMERS

Cardwell transformers; Allen D. Cardwell Mfg. Co.
Chelsea amplifying transformer; Chelsea Radio Co.
Como Duplex transformer; Como Apparatus Co.
Coto audio-frequency transformer; Coto Coil Co.
Globe audio-frequency transformer; Coyne Radio Service
Day-Fan audio transformer; Dayton Fan & Motor Co.
Superadio amplifier unit; De Witt-La France Co., Inc.
Equi-flux audio transformer; James C. Doran & Sons
Dymac audio transformers; Electrical Products Mfg. Co.
Erla audio transformer; Electrical Research Labs.
Essex audio transformer; Essex Mfg. Co.

BATTERIES

"Ace" "A" and "B" batteries; Carbon Products Co.
Flashlight batteries; Champion Carbon Mfg. Co.
Storad "A", "B" and "C" batteries; Cleveland Engineering Labs. Co.
Copper Giant "A" battery; Copper Giant Battery Co.
"Diamond" "B" battery; Diamond Electric Specialties Corp.
Radio-primary battery; Thos. A. Edison, Inc.
Exide "A" and "B" batteries; Electric Storage Battery Co.

BATTERY CHARGERS AND RECTIFIERS

Storad "B" battery charger; Cleveland Engineering Labs. Co.
Esco battery charger; Electric Specialty Co.
Exide rectifier; Electric Storage Battery Co.

BATTERY ELIMINATORS

Dongan "B" eliminator; Dongan Electric Mfg. Co.
Epom "B" battery eliminator; Epom Corp.

BINDING POSTS

"Dixie" engraved binding post; Dixie Supply Co.
Eby binding post; H. H. Eby Mfg. Co.

CRYSTAL DETECTORS

A-1 Galena crystal; California Radio Minerals
A-1 catwhiskers; California Radio Minerals
Carborundum stabilizing detector unit; Carborundum Co.
"Carco" crystal variometer receiving set; Carter Mfg. Co.
"De-tex-it"; Celerundum Radio Products Co.
"Maxitone" crystal; Century Products Co.
Radio reflex crystal; Century Products Co.
"Skylark" detector tip; V. L. Chamberlain
"Clearco" radio crystals; Clearco Crystal Co.
Rasla fixed detector; Davidson Radio Corp.
Universal radio crystal detector; Electric City Novelty & Mfg. Co.
Pyratek fixed crystal rectifier; Erisman Laboratories

DIALS

Cardwell Equitrol; Allen D. Cardwell Mfg. Co.
Day-Fan knobs and dials; Dayton Fan & Motor Co.
Erla dials; Electrical Research Labs.
E-Z-Toon radio dials; E-Z-Toon Radio Co.

FIXED CONDENSERS

Daven Leakandenser; Daven Radio Corp.
Special coupling condenser, type A; Daven Radio Corp.
Fixed condenser; Tobe C. Deutschmann.
Micadons; Dubilier Condenser & Radio Corp.
Dubilier filter condenser; Dubilier Condenser & Radio Corp.
Erla fixed condensers; Electrical Research Labs.

GRID-LEAKS AND RESISTANCES

Centralab adjustable grid-leak; Central Radio Labs.
Centralab radiohm (non-inductance variable resistance); Central Radio Labs.
Crescent Lavite resistance; Crescent Radio Supply Co.
C-H variable grid-leak; Cutler-Hammer Mfg. Co.
C-H resistances; Cutler-Hammer Mfg. Co.
Resistors and grid-leaks; Daven Radio Corp.
Grid-leaks; De Forest Radio Co.
Resistor leak mounting; Daven Radio Corp.
Resisto-coupler; Daven Radio Corp.
Precision resistors; Daven Radio Corp.
Resistance unit; Dubilier Condenser & Radio Corp.
Durham grid-leaks; Durham & Co.
Fil-ko leak; DX Instrument Co.
Fil-ko-resistor; DX Instrument Co.
Lavite resistances; Eastern Coil Corp.
Double grid-leak mountings with condenser clips; Electrad, Inc.
Double grid-leak mountings without condenser clips; Electrad, Inc.
Single grid-leak mountings without condenser clips; Electrad, Inc.
Single grid-leak mountings with condenser clips; Electrad, Inc.
Single mountings with condenser clips only; Electrad, Inc.
Royalty resistances; Electrad, Inc.

HEADPHONES

"Callophone" headset; Callophone Co. of New York.
"Camco" Cannon-Ball headset; Cannon & Miller Co., Inc.
Headset; Connecticut Instrument Co.
Coryphone headset; Chas. Cory & Son.
Crosley headphone; Crosley Radio Corp.
Cyclone headset; Cyclone Radio Receiver Corp.
De Forest radiophones; De Forest Radio Co.
Dictograph headset; Dictograph Products Corp.
Edson phones; Edson Radio Sales Co.
Eisemann headset; Eisemann Magneto Corp.

INSULATORS

Insulators; Circle F. Mfg. Co.
Pyrex insulators; Corning Glass Works.

JACKS

Carter "Hold-Tite" jack; Carter Radio Co.
Carter portable jack; Carter Radio Co.
Receptacle jack; Carter Radio Co.
"Cico" bakelite jack; Consolidated Instrument Co. of America, Inc.
Radjo jacks; Electric City Novelty & Mfg. Co.

KITS

Telos kit; Danziger-Jones, Inc.
Daven resistance-coupled amplifier kits; Daven Radio Corp.
"R.D.X." Reflex receiver kit; Durrant Radio, Ltd.
DXL tuned R.F. kit; D.X.L. Radio Corp.
Resistance-coupled amplifier kit; Electrad, Inc.
Erla Superflex Cir-kit; Electrical Research Labs.

LIGHTNING ARRESTERS

"Little Joe" lightning arrester; Circle F. Mfg. Co.
"Fil-Ko" lightning arrester; DX Instrument Co.
Lightning arresters (indoor and outdoor); Electrad, Inc.

"Keystone" lightning arrester; Electric Service Supplies Co.
Essex lightning arrester; Essex Mfg. Co.

LOOPS

"Calvert" loop; Calvert Specialty Co., Inc.
Carter new loop aerial; Carter Radio Co.
D. T. W. Collapsible Loop; Tobe C. Deutschmann
Erla loop; Electrical Research Labs.

LOUDSPEAKERS

"Callophone" loudspeaker; Callophone Co. of New York.
"Camco" loudspeakers; Cannon & Miller Co., Inc.
"Temple" reproducer; Chicago Signal Co.
Loudspeaker; Columbia Radio Corp.
"Madera" Clearspeaker; Compressed Wood Corp.
"C.I.C." loudspeaker; Connecticut Instrument Co.
Coryphone loudspeaker; Chas. Cory & Son.
Crosley Musicone; Crosley Radio Corp.
Cyclone loudspeaker; Cyclone Radio Receiver Corp.
De Forest loudspeaker; De Forest Radio Co.
Dexter loudspeaker; Dexter Metal Mfg. Co.
Dictograph loudspeaker; Dictograph Products Corp.
Charmitone loud singer; Dual Loudspeaker Co.
Exceltone loudspeaker; Exceltone Radio Sales Co.

MISCELLANEOUS ACCESSORIES

"Gem" radio fuse; Chicago Fuse Mfg. Co.
"Temple" comparator; Chicago Signal Co.
Kester rosin-core radio solder; Chicago Solder Co.
Nestor Bend-Rite; Consolidated Instrument Co. of America, Inc.
Telephone receiver cords; Crescent Braid Co.
Premier 20 foot extension cord with plug; Crescent Braid Co.
Tufglass battery tray; Russell B. Cressman.
Crowe metal marker; Crowe Name Plate & Mfg. Co.
Cuno radio electric match; Cuno Engineering Corp.
C-H Radioloc; Cutler-Hammer Mfg. Co.
Sentinel radio fuses; Davis Electric Co.
De Forest coil mounting; De Forest Radio Co.
A.C. transformer; Dongan Electric Mfg. Co.
Dongan choke; Dongan Electric Mfg. Co.
Window Pane lead-in connector; D.S. DuBois.
Audio transformer, battery charger and battery eliminator coils; Dudlo Mfg. Co.
"Nokorode" soldering paste; M. W. Dunton Co.
Durham base; Durham & Co.
Easy seat cushion; Easy Seat Sales Agency.
Eby binding post strips; H. H. Eby Mfg. Co.
Bezels; Electrical Research Labs.
Solderless connectors; Electrical Research Labs.
Essex radio soldering fluid; Essex Mfg. Co.
Binding post name plates; Etching Co. of America

PANELS

"Bakelite-Dilecto" panels; Continental Fibre Co.
Crowe metal panel; Crowe Name Plate & Mfg. Co.
"Celeron" radio panel; Diamond State Fibre Co.

PHONE PLUGS

Carter One-way plug; Carter Radio Co.
Carter Tu-way plug; Carter Radio Co.
Carter "Imp" plug; Carter Radio Co.
Cico 2-way plug; Consolidated Instrument Co. of America, Inc.
Cico automatic plug; Consolidated Instrument Co. of America, Inc.
Eby phone plugs; H. H. Eby Mfg. Co.

PHONOGRAPH ATTACHMENTS

"C.I.C." phonograph attachment; Connecticut Instrument Co.

POTENTIOMETERS

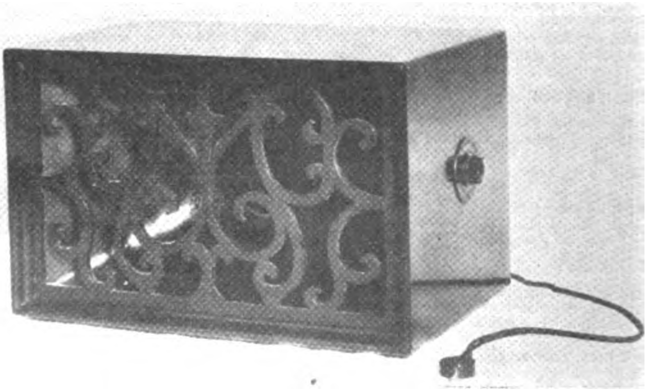
Carter vernier control potentiometer; Carter Radio Co.
Centralab potentiometer; Central Radio Labs.
"Cico" bakelite potentiometer; Consolidated Instrument Co. of America, Inc.
C-H potentiometer; Cutler-Hammer Mfg. Co.
Day-Fan potentiometer; Dayton Fan & Motor Co.
Potentiometer; De Forest Radio Co.
Potentiometer; Eisemann Magneto Corp.
Potentiometer; Electrical Research Labs.

POWER AMPLIFIERS

De Luxe amplifier; Daven Radio Corp.

RADIO CABINETS

"Corbett's" radio cabinets; Corbett Cabinet Mfg. Co.
Adjustable consoles, tables and enclosures; Detroit Woodcraft Corp.
Vulcawood (cabinet material); Diamond State Fibre Co.
Adapto radio cabinet; L. R. Donehue Corp
Eagle console cabinet; Eagle Radio Co.



A HIGH QUALITY CABINET SPEAKER

Name of instrument: Cabinet reproducer.

Description: This new reproducer is equipped with a long horn of special shape and a variable reproducing unit. The adjustment for this unit is on the right side of the cabinet, which is finished in highly polished mahogany. The cabinet is equipped with a cord for attaching to the radio receiving set itself. The construction of both the unit and the horn shape is such that the cabinet speaker produces the low tones and the high tones with a natural mellow quality.

Usage: In connection with a radio receiving set as a reproducer.

Outstanding features: Neat appearance. Good tone quality. Very fine appearance.

(*Further details furnished on request*)

RADIO-FREQUENCY TRANSFORMERS

Cardwell "Toro-Tran"; Allen D. Cardwell Mfg. Co.
"Carco" neutroformer; Carter Mfg. Co.
Celco intermediate-frequency amplifying transformer; Central Engineering Labs.
Tuned-intermediate-frequency transformer; Como Apparatus Co.
Coto radio-frequency transformer; Coto Coil Co.
Harper Metaloid; Cribben Radio Corp.
Day-Fan radio-frequency transformer; Dayton Fan & Motor Co.
De Roy phusiformer; De Roy Radio Corp.
Superadio radio-frequency amplifier unit; De Witt-La France Co., Inc.
Dubilier Duratran; Dubilier Condenser & Radio Corp.
Low-loss radio-frequency transformer; Eastern Coil Corp.
Eisemann radio-frequency transformer; Eisemann Magneto Corp.
Radjo low-loss radio-frequency transformer; Electric City Novelty & Mfg. Co.
Erla transformers and balloon circloid radio-frequency coupler; Electrical Research Labs.

RECEIVING SETS

"Cardwell" receiver; Allen D. Cardwell Mfg. Co.
Chelsea receiver; Chelsea Radio Co.
Clear-o-dyne receiver; Cleartone Radio Co.
Goldcrest Cleartone receiver; Cleartone Radio Co.
Cleartone "90" receiver; Cleartone Radio Co.
Crosley receivers; Crosley Radio Corp.
"Teledyne" receiver; Cutting & Washington Radio Corp.
"Towne & Country" receiver; Cutting & Washington Radio Corp.
C & W receiver; Cutting & Washington Radio Corp.
Cyclone radio receiver; Cyclone Radio Receiver Corp.
Day-Fan receivers; Dayton Fan & Motor Co.
De Forest receivers; De Forest Radio Co.
Dexter DX-5 receiver; Dexter Metal Mfg. Co.
Dynergy radio set; Dynamotive Radio Corp.
Eaglet neutrodyne; Eagle Radio Co.
Echophone V-3, F5 and portable; Echophone Radio, Inc.
Eisemann receivers; Eisemann Magneto Corp.
Erla knockdown receiver; Electrical Research Labs.
De Luxe Heteroplex receiver; Elvin Radio Co.
Gold Medal receiver; Eureka Outlet Co.
Superheterodyne receivers; Experimenters Information Service, Inc.

RHEOSTATS

Vernier rheostat; Carter Radio Co.
Carter "Imp" rheostat; Carter Radio Co.
Centralab rheostats; Central Radio Labs.
Cico rheostat; Consolidated Instrument Co. of America, Inc.
C-H rheostat; Cutler-Hammer Mfg. Co.
Day-Fan rheostat; Dayton Fan & Motor Co.
De Jur 1-hole rheostat; De Jur Products Co.
Fil-ko-stat; DX Instrument Co.
Eagle revolving resistor rheostat; Eagle Radio Co.
Rheostat; Electrical Engineering Equip. Co.
Erla Precision rheostat; Electrical Research Labs.

SOCKETS AND ADAPTERS

Camfield "Bull Dog Grip" socket; Camfield Radio Mfg. Co.
V. T. socket; Circle F. Mfg. Co.
Coto tube socket; Coto Coil Co.
C-H socket; Cutler-Hammer Mfg. Co.
Sockets; De Forest Radio Co.
Duray All-Glass viralon socket; Duray Radio Corp.
Eby cushion socket; H. H. Eby Mfg. Co.
Universal socket; Electric City Novelty & Mfg. Co.
Erla socket; Electrical Research Labs.
Essex socket; Essex Mfg. Co.

SWITCHES

Carter "Imp" switch; Carter Radio Co.
Carter inductance switch; Carter Radio Co.
Carter jack switch; Carter Radio Co.
Carter Dialite; Carter Radio Co.
Celco indicating switch; Central Engineering Labs.
Centralab battery switch; Central Radio Labs.
"C.I.C." lock "A" battery switch; Connecticut Instrument Co.
Cico battery switch; Consolidated Instrument Co. of America, Inc.
C-H switches; Cutler-Hammer Mfg. Co.
De Forest switches; De Forest Radio Co.
Multiple switch; Eagle Radio Co.
Radjo switches; Electric City Novelty & Mfg. Co.
Arkay cam switch; Essex Mfg. Co.

TESTING INSTRUMENTS

Cell-O-Meter; Cellokay Mfg. Corp.
SOS hydrometer; Chaslyn Co.
Dongan high-resistance voltmeter; Dongan Electric Mfg. Co.

TOOLS AND EQUIPMENT

"Reachit" wrench; Caufman & Clough Co.
Coburn "Unitool"; Coburn Tool Co.

TUBES

"Ceco" vacuum tube, type 201-a; C. E. Mfg. Co.
Power amplifier tubes E & F; C. E. Mfg. Co.
Cleartron model C.T. 100; Cleartron Vacuum Tube Co.
Hi-constron vacuum tube; Cleartron Vacuum Tube Co.
"Sodion" tubes; Connecticut Telephone & Electric Co.
Magnatron detector tube; Connewey Electric Labs.
Rex. tubes for "B" eliminator; Connewey Electric Labs.
Cunningham tubes; E. T. Cunningham, Inc.
Daven tubes; Mu-6 and Mu-20; Daven Radio Corp.
De Forest audions; De Forest Radio Co.
Protect-o-tube; Don Mac Co.
Diode detector tube; Electrad, Inc.
Everest "World Top" tube; Everest Mfg. Co.

TUNING INDUCTANCE UNITS

Radio-frequency tuner; Chelsea Radio Co.
Antenna tuning unit; Chelsea Radio Co.
Coto compact moulded variometer; Coto Coil Co.
Coto compact moulded variocoupler; Coto Coil Co.
Coto honeycomb coil; Coto Coil Co.
Day-Fan variometers; Dayton Fan & Motor Co.
Day-Fan variocouplers; Dayton Fan & Motor Co.
Day-Fan detector unit; Dayton Fan & Motor Co.
De Forest honeycomb coil; De Forest Radio Co.
Variometer; De Forest Radio Co.
Eastern coupler; Eastern Coil Corp.
Three-circuit tuner; Eastern Coil Corp.
Low-loss coils; Eastern Coil Corp.
Cockaday coils (silk wound); Eastern Coil Corp.
Variometer; Eisemann Magneto Corp.
Variocoupler; Eisemann Magneto Corp.
Verni-tuner; Electrad, Inc.
Short-Wave coil; Electric City Novelty & Mfg. Co.
Radjo low-loss 180 three-circuit tuner; Electric City Novelty & Mfg. Co.
Duo-lateral coils; Electric Products Mfg. Co.
Pull Mall variocoupler; Essex Mfg. Co.

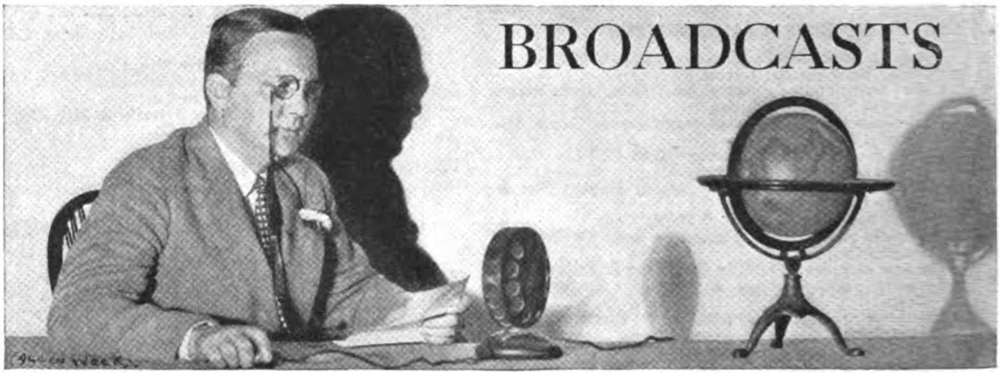
VARIABLE CONDENSERS

"Cardwell" condensers; Allen D. Cardwell Mfg. Co.
Chelsea variable condenser; Chelsea Radio Co.
Straight-line wavelength condenser; Chelsea Radio Co.
Chelten "Special" condenser; Chelten Electric Co.
Connecticut condenser; Connecticut Telephone & Electric Co.
Coto variable condenser; Coto Coil Co.
Crest convertible condenser; Crest Radio Corp.
Rasla Strate-Lyne frequency condenser; Davidson Radio Corp.
Variable condenser; De Forest Radio Co.
Superadio condenser; De Witt-La France Co., Inc.
Duplex condensers; Duplex Condenser & Radio Corp.
DXL condenser, model C; DXL Radio Corp.
Eagle condenser; Eagle Radio Co.
Eisemann condenser; Eisemann Magneto Corp.
Erla Miniloss condenser; Electrical Research Labs.
Elraco Precision condenser; Elgin Radio Corp.

WIRE

Bus wire, square and round; Edward N. Cook Plate Co.
"Blue Ribbon" battery cable; Crescent Braid Co.
Enameled, cotton-covered, silk-covered bus bar, magnet and aerial wire; Dudlo Mfg. Corp.
Skware flex bus wire No. 12; Essex Mfg. Co.

¶ THE *article "How to Build and Operate a Low-power Transmitter" (which was crowded out of this issue), will appear in* POPULAR RADIO *for next month—April.*



BROADCASTS

CONDUCTED BY J. ANDREW WHITE

In this department the Dean of Broadcasters—whose voice is known to millions of broadcast listeners—records items of interest and value to all radio fans everywhere.

Broadcasting College Courses to Farmers

The announcement that an expert has been named to take over control of the radio activities of the Department of Agriculture brings to mind the fact that Secretary Jardine himself, while still president of the Kansas State Agricultural College, was one of the early broadcasters of agricultural extension work. It is beyond question that a systematic development of a definite service will carry pleasure and profit beyond calculation into the homes of the farm families; and the cooperation of federal, state and local agencies as planned in the new program gives promise of realizing the hope that cold and formal lectures will be shelved and that regular classroom instruction by radio will be instituted, with students regularly registered and examined and given full credit for work performed. This was the development of agricultural broadcasting foreseen by William A. Wheeler, member of the Interdepartmental Radio Board, in recommending specific reservations within the broadcast bands of wavelengths for dissemination of agricultural material. Adoption was secured for the resolution which carried the recommendation, so the day should not be far distant when it will be possible for all the major agricultural colleges in the country to make their courses available to the entire farm population instead of reaching, as now, a comparatively small percentage of the folks they are designed to help.

* * *

Jazzing the Deaf by Radio

Bitter opponents of jazz are faced with a counter-claim now that the pronounced rhythm of this class of music emphasized by beating of the drums and piercing notes of the "hot" cornet playing have humanitarian value—that through certain strains vibrations are set up which enable the deaf to hear. This information has been conveyed to Paul Ash, orchestra leader and radio star of KYW, in letters from several women who explain that these are the only sounds they have been able to hear and that they enjoy the jazz music although otherwise deaf. A famous ear specialist of Chicago has become interested in the subject, it is reported, and is conducting a series of tests to determine the possibilities of utilizing this means of "bone conduction" of sound so that those who have lost normal hearing may through radio have the pleasures of music. When the unique investigation has been completed the renowned specialist promises the issuance of a report and a test program over the air is to be given with deaf persons asked to "listen in" and to report what they "hear."

* * *

Warnings by Wireless

When a dozen or so tributaries hereafter are inclined to go on a rampage, and flood or deposit ice break-ups into swollen streams feeding into the Ohio River the serious changes thus brought about will be known immediately to navigators, shippers, farmers and others along a 1,000 mile stretch from Pittsburgh to Cairo. Daily radio broadcasts of the weather and a report of the river and its stages form the basis of the new and useful report which has been added to the varied forms of service originating at WLW.

* * *

Radio Service to Newspapers

One of the first impediments to the selection of whatever might be thought useful to air entertainment programs was the opposition encountered by pioneer broadcasters from the news gathering agencies which furnish the newspapers of the country with countless items daily. In the earliest days of broadcasting news bulletins were a regular feature; then in most instances they were dropped out only to reappear within the last year or so in various forms and increasing volume. The restrictions of the earlier days having been gradually lifted, it is interesting to note that this has been largely because radio has proved to be of inestimable aid to the great system of news distribution in times of emergency. A number of instances might be cited, but the public is more or less familiar with these and will be more interested to learn of the latest arrangement made to provide the protection of radio for newspaper readers in the Rocky Mountain territory. This has been brought about by completion of plans with KOA, by which that station at Denver in cooperation with the United Press Association will flash the big news events of the day if landwire communication becomes blocked during severe storms or is crippled through blizzards or washouts. The news is to be read into the microphones at stated intervals and editors all over the territory will be equipped to take down the items in shorthand.

* * *

The Pending Radio Legislation

READERS have indicated a considerable interest and some degree of confusion in their minds as to the radio legislation proposed for the present session of Congress. While it cannot be anticipated what changes may take place between the time this is written and when it appears in print, the situation, briefly stated, is this:

There are two bills before Congress providing for the proper policing of the ether, as desired by the Department of Commerce. One is sponsored by Representative White of Maine; and a similar bill has been introduced in the Senate by Dill of Washington. Chairman of committees of both branches of the legislative bodies abandoned the original intention of arranging for joint hearings but arrangements were made for the convenience of witnesses to appear before both bodies at practically the same time. It is thought that most of those who will appear in each instance will be called, as the principal purpose of the hearings will be to give supplementary information and to answer the questions of the committeemen who may desire slight modification or amendment of the bills as drawn. As the bills stand at this writing both cover the legislative requirements as outlined by the recent National Radio Conference, except that they do not establish fees for licensing stations and operators, or give any mention to the recommendation to place a ban on oscillating receivers.

* * *

How Europe Is Regulating Its Broadcasters

EUROPEAN regulations affecting broadcasters are being developed along lines very similar to those recommended for adoption in the United States. At a conference of engineers at Geneva a 10 kilocycle separation was urged for allocation of wavelengths within the bands most familiar to listeners, and a separation of 20 kilocycles between the transmitting channels of the long wave stations. In the effort to clear up interference overseas the drastic recommendation was included to set aside requests for allocation of any of the channels between 300 and 500 meters, and that no consideration be given to applications for such licenses from new stations except in very special cases. This parallels the recommendation made by our own conference at Washington. It means of course that Europe has plenty of stations and that newcomers should be made to accept whatever is open below 300 meters and above 500 meters. Furthermore, applications are to be considered in the light of the length of service rendered by the station, the number of listeners it serves, its range, and how

Pacific & Atlantic

MAKING THE OCEAN'S FLOOR HIS STUDIO

With a specially constructed microphone and a radio receiver inside of his helmet, Herr Rarmstorf, the famous diver, went to the bottom of the North Sea near Heligoland to broadcast a talk to the fans of Europe. Here he is just beginning his descent to his lonely studio it fits in with the necessity of having several stations serving a multiplicity of listeners speaking different languages. Judged by the foregoing requirements, however, it was decided that priority rights must be established as there are not sufficient channels to serve all future needs between 200 and 600 meters. At some later date consideration is to be given to the bands below 200 meters. Incidentally, the bothersome operators of oscillating receivers abroad escape also, no action being taken against regenerative receiving sets.

* * *

The New "Community Concerts" by Radio

Since Cincinnati blazed the way with its series of twenty community concerts through WSAI three other cities have seen the value of setting their community favorably before the horde of radio listeners. St. Louis has followed the praiseworthy example and so has Davenport, Iowa, with San Antonio, Texas, considering the matter seriously. And now a State has fallen in line, with the announcement by Governor M. E. Trapp of Oklahoma to set aside a day to be known as "The Voice of Oklahoma Day" in an effort to raise a $100,000 fund to establish a radio station to present the charms of that particular section of the southwest. That this useful movement is growing cannot be but a cause for congratulation, for, as expressed by the Chairman of the Cincinnati Chamber of Commerce, Edward J. Hoff, those in charge of the pioneer effort along this line will be only too happy to assist others and advise them in the light of experience, which may be summed up in this extract from his statement to the San Antonio committee: "We know the pitfalls; we know the objections that will be met with; we know the difficulty of raising money to pay the bills; we know that if you don't raise sufficient money, you can't put on high class programs; we know that if you don't put on high class programs your advertising would be against you rather than for you."

Pacific & Atlantic

A BOTTLE OF RADIO MUSIC

Even empty whiskey bottles have a use, finds Victor La Force—if you can get your radio receiver inside of one. He built a complete crystal receiver in this bottle within seven hours.

* * *

What Re-broadcasting Does for the Fan

There is no small degree of pleasurable excitement in picking up the music and speech from stations in foreign lands, and more of such thrills are coming to us regularly with the rapid development of re-broadcasting and superpower. As we await the day, however, when such reception will be merely an incident in the program of each night, there is a slight shock for an American who picks up a London broadcast announcement and finds the casual statement in print, that: "The Radio Revel, to be held by the B.B.C. and the Faculty of Arts at Olympia, will include dance music from Berlin, Amsterdam, Paris, Brussels, San Sebastian, Madrid, New York and Pittsburgh."

* * *

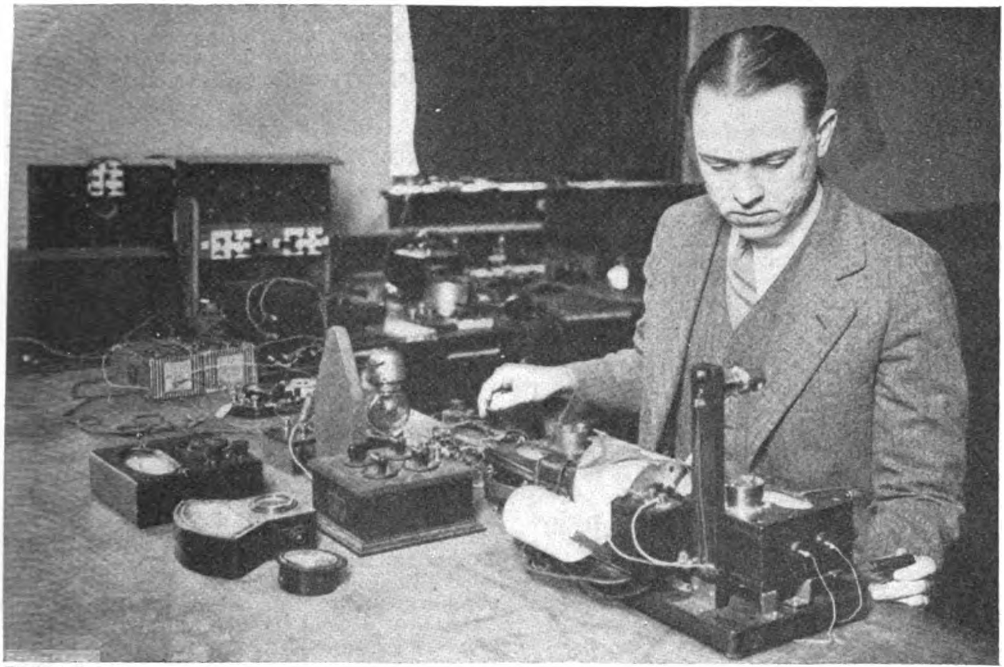
The Best Location for DX Reception

Brandamore's claim of being the prize location for long distance reception, which was heralded far and wide in the press not so long ago, has suffered a severe setback with the disclosure that a railway telegraph operator located at the small Pennsylvania town has admitted his reception of distant radio stations on an ordinary telephone line was a hoax. For two years Earl Davidson mystified experts who were sent to investigate the phenomena. It was quite common for the employees of the railroad to lift the telephone receiver to report a train and pickup a radio program being broadcast from Atlanta, San Francisco and occasionally from stations overseas. A concealed radio set connected to the telephone lines by means of a device worked out by Davidson, details of which he did not disclose, lay at the bottom of the mystery which has now been cleared up. Davidson lost his job as the result of the hoax.

* * *

The Radio Play Contest

The Hoover Cup, a silver trophy, is to be given to the winner of the radio play contest along with the $500 cash prize originally put up by WLS to create for the radio drama the equivalent of the scenario in motion pictures. The contest closed on February 1 with the announcement that the committee of judges is headed by Stuart Walker and the others to pass upon the plays submitted are Augustus Thomas, playwright; George Arliss, actor; and James O'Donnell Bennet, dramatic critic:



Harris & Ewing

A RADIO SET MADE TO RECEIVE STATIC

This apparatus tunes in on all the static it can find while all other receivers are doing their best to avoid it. It is the static recorder employed by the Bureau of Standards at Washington to find out the main characteristics of this type of interference, especially the wavelengths upon which it operates.

The Broadcasting of Copyrighted Music

THE long standing controversy between radio and musical interests about which I wrote some months ago as one affecting the public in the matter of whether or not radio listeners would continue to hear new and good music on the air, was the subject of a three-day discussion at the Fourth Annual Radio Conference at Washington. The basis of disagreement is the copyright law and although the sessions were hectic, no agreement was reached between the broadcasters and the Society of Authors, Composers and Publishers. Both sides agreed that there is only one solution to the problem, but since neither seemed willing to advance that solution except in private, and recommended to the conference that legislation be enacted to settle the question, the whole matter was tabled by recommendation of Secretary Hoover, who asked that further effort be made toward reconciliation. The music interests asked for payment each time a number is broadcast, payment to be on the basis of the record made of the daily renditions at each station with periodical settlement of the required fee as compensation to the music society. The amount of bookkeeping involved was thought to be an obstacle to adoption of this system, but there was no opposition to the plan on the part of the National Association of Broadcasters; the spokesman for that organization, Paul Klugh, however, insisted that the music interests would not consider such a proposal unless forced to do so by Congressional action. Although this method of payment was considered to be the logical plan upon which both sides could get together, no action was taken, and although a long fight is thought to be in prospect it seems only a matter of time when agreement upon this sensible solution will be reached.

* * *

Italy Adds to the Ethereal Choir

THE projected station at Milan, Italy, will be similar to 2LO at London, equipped to broadcast with 12 kilowatts, on 384 meters. It is being erected by the owner, the Union Radiofinica Italiana.

* * *

Radio Sets for the Blind

THE worthy purpose of providing radio sets for the blind, the campaign for which it was my great privilege to open with a microphone introduction of the remarkable Helen Keller, more than a year ago, goes on apace with Boy Scouts in forty-eight states installing free of charge the two-tube outfits provided by the American Foundation for the Blind for afflicted persons who cannot afford to purchase a set. Within three months joy has been brought to 650 homes through this work, thus multiplying by seven the resolution of the boys to do a good turn daily.

On the Trail of Old Man Static

There is still no explanation of why radio reception should be stronger in winter, when static electricity leaps out of one's hair or sparks out of the rug at one's feet, and weak in summer when there are apparently no static charges about us. This is the view held by J. K. Smith of the Stewart-Warner corporation, under whose direction an investigation of "fading" on a scale never before attempted has been carried on through twenty observation stations. Readings taken every two minutes during the period of the tests are to be charted and the results averaged and plotted on a map similar to that issued by the Government Weather Bureau. A comparison of fading and static curves with those of the weather map should be of value in determining the effect of weather on radio reception, for reception in the year past failed to follow the accepted rules. There were clear cold nights when it was impossible to hear stations 500 miles distant, and there were warm, wet nights entirely free from static and perfect for broadcast reception from distant points.

* * *

Linking the Home Telephone to Radio

A number of times within my recollection word has been received from some radio fan telling how he connected up his radio set and gave the neighbors on his party telephone line a treat; in fact, these reports are received with such regularity that the latest one from Guy Oglesby of Colony, Oklahoma, has added interest only because the connections were made with twenty farmers, instead of three or four. Quite a different matter, however, is the report received from R. A. Nevin of Hiawatha, Kansas, and made public by KOA. It appears to be a regular thing there for the telephone officials to provide radio loudspeaker service to widely scattered subscribers, an arrangement about which Mr. Nevin makes this comment: "This system is ideal except that we take what the operator gives us. On the whole, however, he gives us the best."

* * *

How Zanesville Reduces Interference

There is a ten dollar fine coming to the resident of Zanesville, Ohio, who uses a vibratory battery charger during the periods of broadcast reception, which is designated as between the hours of six in the evening through to five in the morning, in an ordinance recently passed, designed to keep the ether free from local interference.

* * *

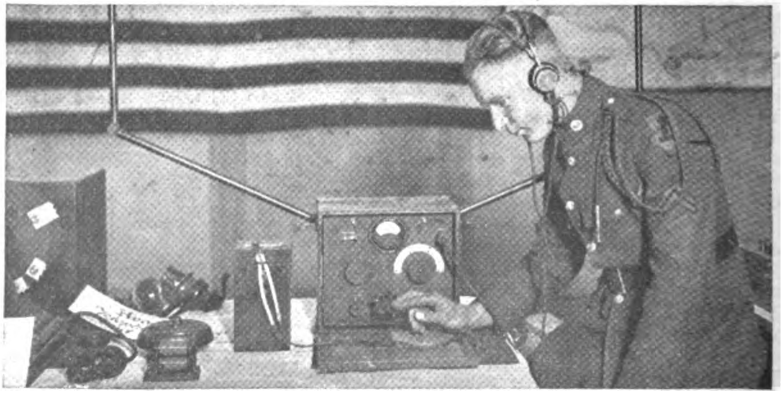
Sweden Profits from Broadcasting

Sweden is making money out of broadcasting. The Telegraph Administration came to the close of the year with a net profit of more than 150,000 crowns and the broadcasting company which divides things up with the Government also reports large profits. More than 120,000 licenses were taken out by the Swedish fans and it is proposed that a reduction in the license fee is in order for 1926. The revenue from licenses is divided fifty-fifty between the Telegraph Administration and the broadcasting company, but of the other income the radio company receives 75 percent.

* * *

The "Coming International Radio Conference"

At least sixty countries will be represented at the great International Radio Conference to be held at Washington within a few months, for the State Department has already received three score acceptances to its invitation to participate.



Kadel & Herbert

A RADIO SET WITH A TWO-METER RANGE

This loop transmitter and receiver is one of the most efficient sets used by the U. S. Army, although it can only operate between 72 and 74 meters. On this short wavelength range, however, it can receive ten different stations 1/5 of a meter apart. The loop antenna is enclosed in a metal frame.

MAR 2 1926

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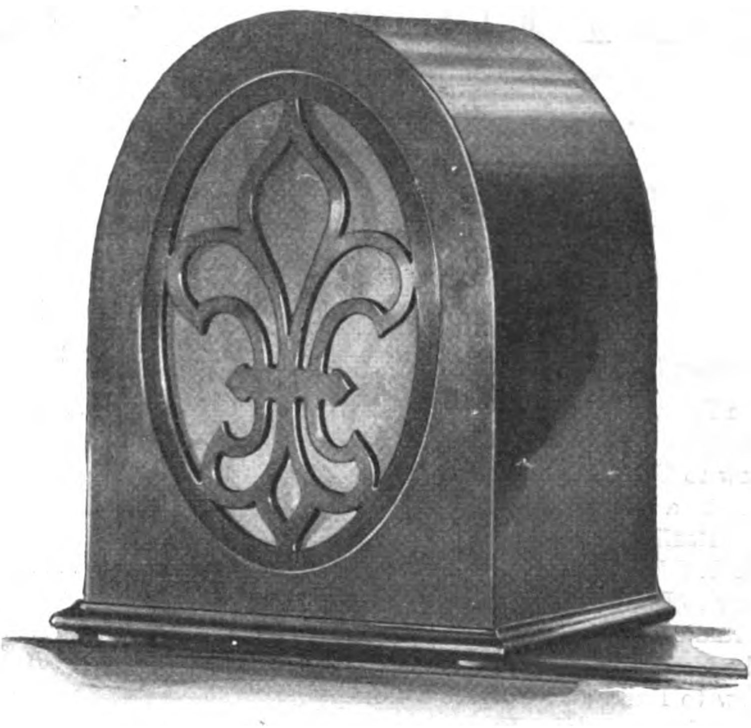

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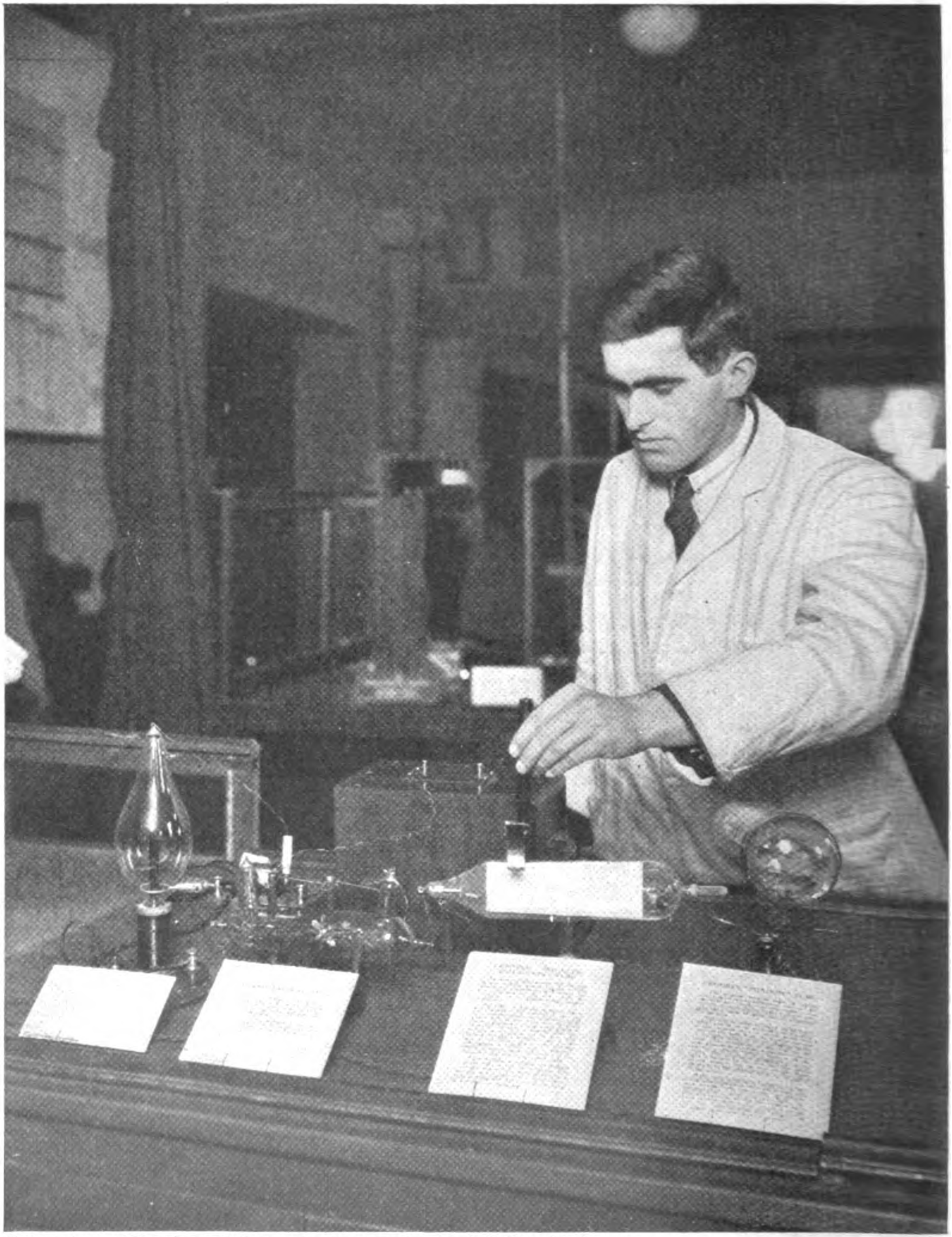
L W Austin

PRESIDENT, INTERNATIONAL UNION OF SCIENTIFIC RADIO TELEGRAPHY



From a photograph made especially for POPULAR RADIO by Campbell-Gray, London

The Fastest Projectiles on Earth

*By special apparatus electrons can be separated from the atoms to which **they belong and shot out** in streams, as is being done in this special vacuum tube **demonstrated recently at the** Science Exhibition at Wembley, England. The lighter streak on the white, **phosphorescent** screen shows how the path of the electron stream is bent by the magnet **which the operator holds.** The speed of electrons in such streams may exceed **a million miles a minute.***

Popular Radio

VOLUME IX APRIL, 1926 NUMBER 4

1,000,000 Miles a Minute

Radio waves are the speediest thing in the universe. Only slightly less speedy are some of the tiny electrons which fly about inside the atoms of matter. The interaction of the radio waves with these electrons, for example, when a wave reaches a receiving antenna, introduces us to an astounding new world of vast speeds and of infinitesimal time units—a world which this article describes.

By E. E. FREE, PH.D.

IF you leave a silver dollar on your work table over night, and if you are reasonably lucky in your house companions, the silver dollar will still be there in the morning. In any event it will not have run away all by itself.

But if you leave the family cat on the work table the result will probably be different. Kitty's whereabouts in the morning are beyond prediction.

That is the difference between motion and an apparent lack of it.

The cat possesses a mechanism of muscles and nerves and whatnot which makes him self moving. The silver dollar —as it seems—does not.

Nevertheless it would be a great mistake to assume that the silver dollar was motionless. In fact, it contains a stupendous amount of motion—millions of times more than that exhibited by a jumping cat. All this motion is internal. It is locked up, under ordinary conditions here on earth, inside the atoms of silver in the metal.

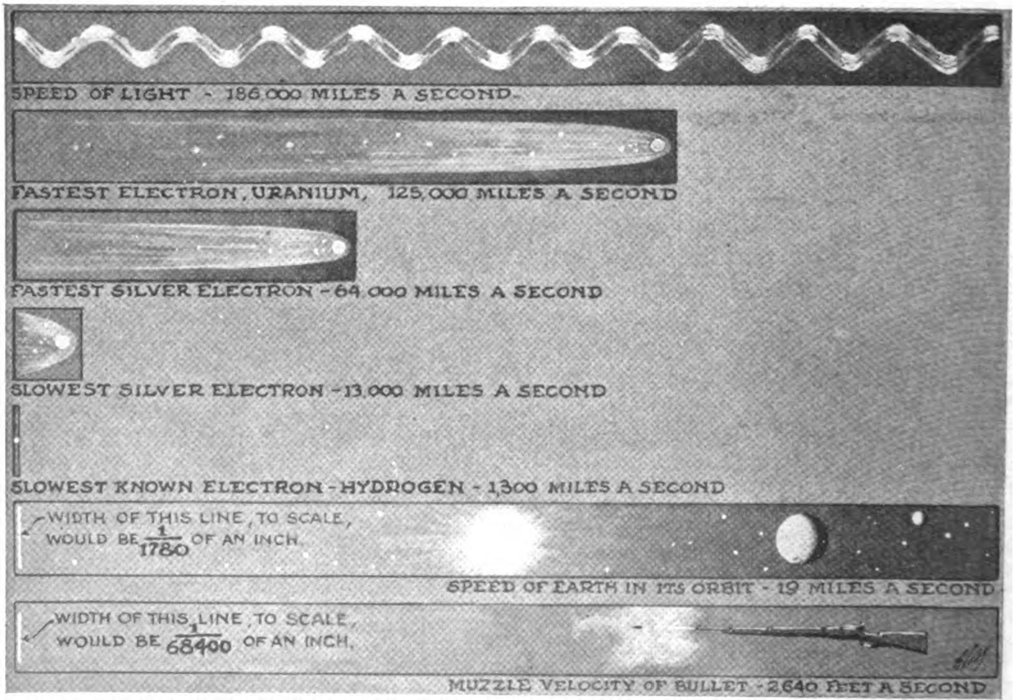
All atoms are believed to consist, you remember, of two kinds of very tiny separate particles. One kind are electrons, the same electrons which operate our vacuum tubes and energize our antennas and are so generally useful and indispensable in radio. The other kind of particles are the positive electric particles or protons. The simplest known atom is that of hydrogen gas. This has only two particles; one electron and one proton. The proton is at the center of the atom and the single electron revolves around it, much as our earth revolves around the sun. Other atoms are constructed similarly, but are more complex. The silver atom, for example, has a clump of some one hundred and seventy protons and electrons for its atomic sun. Around this revolve forty-seven electron planets, each in its own orbit. There are atoms still more complicated. One of them, uranium, contains nearly five hundred protons and electrons, 92 of the electrons being planetary ones and revolving in a system of orbits so complicated that we do not yet understand it at all.*

The speeds with which these electron planets traverse their orbits inside the atoms are so enormous that it is virtually impossible to comprehend them. The fastest of them are believed to be two which occupy the inmost orbits in the atom of uranium. Their speed has been calculated as nearly 125,000 *miles a second.*

Even the slowest of all known electron speeds, that of the single electron of the hydrogen atom, is believed to be over 1,300 miles a second. In the atoms of the silver dollar the speeds range from about 12,000 miles a second up to over 64,000 miles a second. A million miles a minute is slow in atom land. The uranium electrons reach three hundred times as much.

These figures are as meaningless to most of us as is the difference between a billion dollars and a trillion dollars. We never hope to see either of them. But let us try—for the case of the speeds, not of the dollars—some comparative illustrations.

Suppose that you have a family cat who is a great jumper and suppose that by some magical gland food or something you activate the cat to still greater prowess. Suppose he grows able to



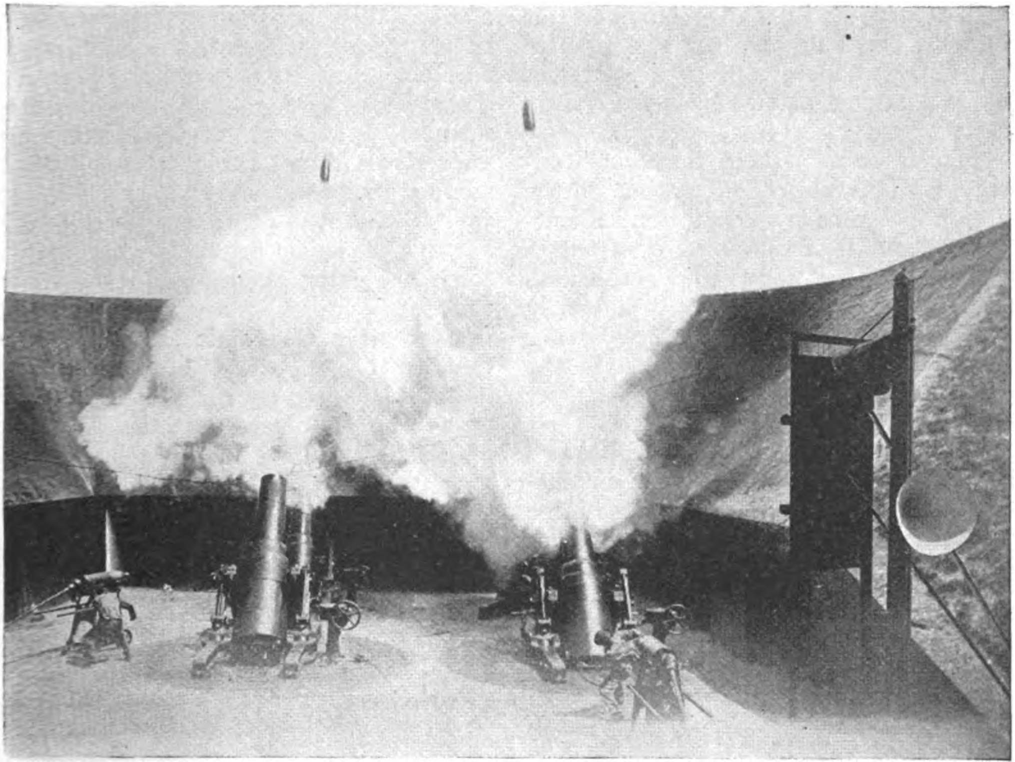
From a drawing by Arthur Merrick for POPULAR RADIO

RADIO'S NEAREST RIVALS IN SPEED

The length of the wavy line at the top represents the speed of radio waves and of light, which are the fastest things in the known universe. Below are a few electron speeds, all represented to scale. Ordinary speeds, like that of a rifle bullet, are very slow in comparison, as is indicated on the bottom line.

---

*For an outline of modern atomic theory see: POPULAR RADIO for January, 1924, pages 41-48; for April, 1924, pages 319-327; for December, 1924, pages 546-553. Sir William Bragg's articles on the atom in POPULAR RADIO for August and September, 1925, January, 1926, and in this issue, may be consulted also. One of the best popular books on atomic theory is "Atoms and Rays," by Sir Oliver Lodge, George H. Doran Company, New York City, 1924.



Brown Bros.

THESE FLYING SHELLS ARE REALLY SLOW

Although the shell leaves a big gun at a speed which makes it totally invisible except to the most rapid of instantaneous cameras, this speed is so much slower than the speeds of radio waves that an ordinary radio wave can pass back and forth along an antenna more than two hundred thousand times while the shell is moving as far from the gun mouth as you see it above.

jump as fast as those speediest electrons in the silver dollar, those which move at the rate of 64,000 miles a second or more. Of course, such a cat would not remain very long on earth, for one good jump would take him off beyond the other side of the moon.

Suppose that this activated cat and the silver dollar are both resting on your work table and suppose that the cat, as he jumps, knocks off the silver dollar so that it falls to the floor. Every one knows that it takes no great time for the dollar to fall. For most people, it falls too rapidly for muscular motion, no matter how quick, to catch it.

But the dollar falls far more slowly than the cat jumps. If all this happens in New York City and if the cat jumps west, kitty will be passing San Francisco when the dollar has fallen about nine inches of its way to the floor. If the cat is speeded up a little more, so that its speed equals that of the fastest electrons in the atom of uranium, he will be on the other side of the moon before the clock ticks twice. If a man fell toward the center of the earth with the speed of these atomic electrons he would go clear through to China while an ordinary individual was falling down on a slippery pavement .

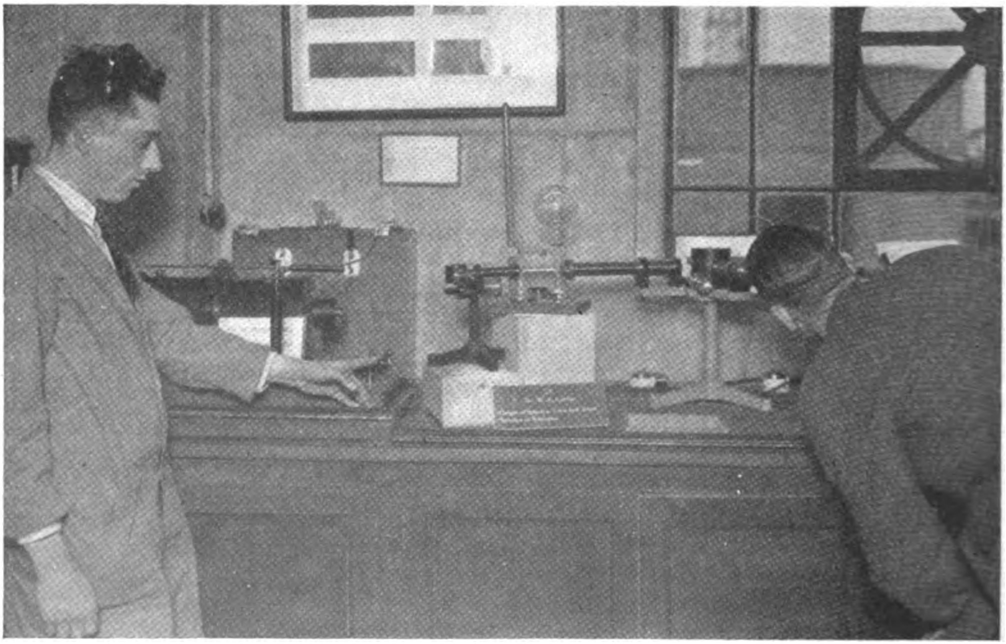
Other comparisons are possible on the basis of the amount of energy in the motion. A speeding locomotive, for example, is a very energetic thing. If it hits a solid obstacle like a wall or another locomotive, a vast amount of energy is set free. Everything is smashed. It would take many men exerting energy with sledge hammers for days to break up the iron and steel of an engine as thoroughly as it is broken up in a second or two by a really first class wreck.

Motion means, then, that much energy is involved. The motion of the atomic electrons is no exception. Knowing the speeds of the flying electrons in a silver dollar, it is possible to calculate without difficulty the energy that they possess. This turns out to be actually more than the energy involved in the speeding locomotive. It is, in fact, over four hundred times as much.

A full sized railway wreck, with two heavy locomotives and trains of cars hitting each other head on, will set free only about as much energy as is contained in the motions of the electrons in ten cents' worth of silver.

Needless to say, if one suddenly stopped this electronic motion in silver or in any other metal, the energy set free would be so vast that the entire atomic structure would probably disintegrate. If some magician spoke to your silver dollar the fatal word that stopped its motion suddenly, that dollar would instantly evaporate into white hot gas. It is just as well, perhaps, that today's scientist-magicians do not know this magic word or are likely, in the present state of atomic knowledge, to discover it.

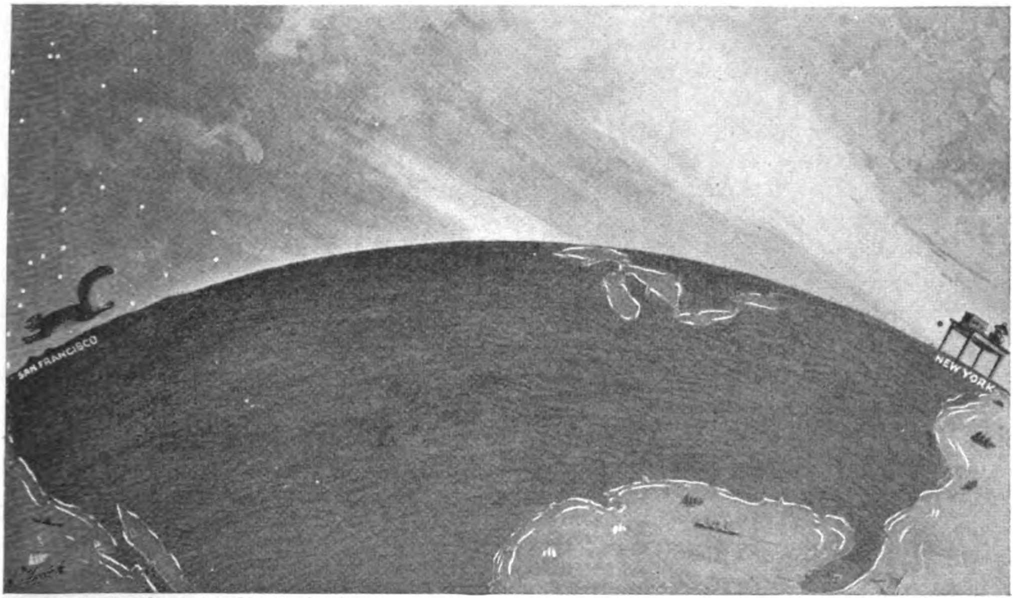
But what, you ask, has all this to do with radio? Granted that the electrons inside a silver dollar are executing a very speedy imitation of a whirling dervish, granted that the energy contained in them is vaster than a railway wreck and that their motion is comparable in agility to that of an imaginary thousand-league cat; what of it? Does this help



From a photograph made especially for POPULAR RADIO by Campbell-Gray, London

SPEEDY ELECTRONS BREAK UP ATOMS

In this apparatus, exhibited recently at the Science Exhibition, at Wembley, England, a stream of high-speed free electrons is passed through nitrogen gas in the glass tube in the center. The atoms of nitrogen are hit by the electrons and disrupted. As they return to their usual forms light is produced. The observer is watching this light through the spectroscope. This photograph and that used as the frontispiece are published by special permission of the British Empire Exhibition Committee of the Royal Society.



From a drawing by Arthur Merrick for POPULAR RADIO

ELECTRON SPEED WOULD REACH PACIFIC IN AN INSTANT

Suppose that a cat could jump as fast as an electron does in the atoms of a silver dollar. And suppose that the cat jumped just as a dollar fell off a table. The cat would pass San Francisco before the dollar had fallen a foot toward the floor. This gives you some faint idea of the tremendous speeds which exist inside an atom.

us to detect radio waves any better or to reach out for longer distances with our new short-wave transmitters?

Not yet, perhaps. But the last word in radio has not been said. There are still worlds to conquer. The answer of the future concerning the value of studying atomic speeds and atomic time units may be very different to the answer one might be tempted to give today.

It is really this matter of our time units which is most important. We humans live in a world for which a second seems a short time and a million years a very long one. Yet there exists, we know, the greater universe of the stars, in which a million years is a very short time indeed. The age of even so young and transient an astronomic body as our earth is reckoned in billions of years and the age of a really vast sun in hundreds of billions.

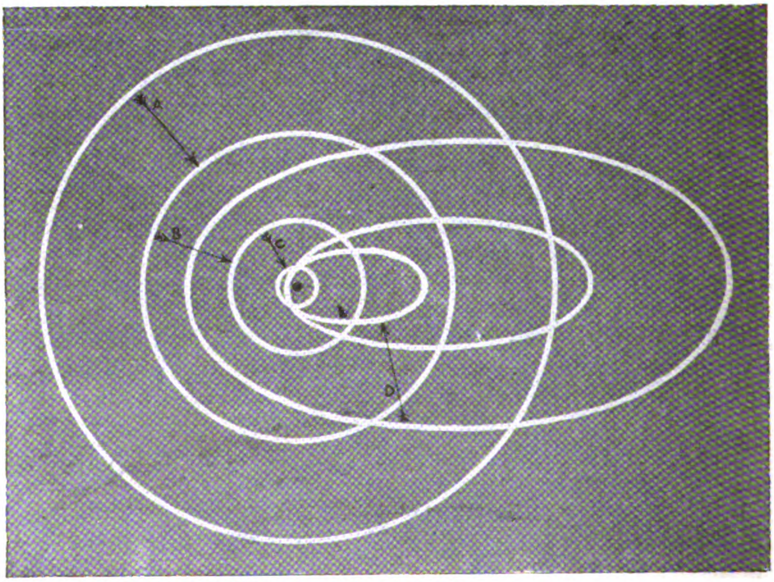
Just so there exists a tinier world of atoms in which the time units are far shorter, in comparison with ours, than ours are in comparison with the times which mark the lives and deaths of stars. Our fundamental time unit is the day, the time of one revolution of the earth about its axis. The fundamental time unit for a hydrogen atom may be taken, perhaps, as the time in which its single electron revolves about the atomic nucleus. This time is approximately one six-quadrillionth of a second. Over six million billions of these revolutions occur in each of our seconds. Were this hydrogen-atom time unit taken as equivalent to a day, the time measured by a terrestrial second would stretch out, in comparison, for nearly eighteen trillion years; an even vaster difference, you notice, than exists between our human time-scale and what is now believed to be the time-scale of the stars.

When their time units are considered, radio waves and the still shorter ether waves that constitute light and X-rays and gamma rays belong to the realm of the atoms rather than to the time-world which is familiar to us. Ether waves move with the greatest speed now known. They probably possess the greatest speed which is possible to anything inside our universe. They are faster, even, than the speediest electrons in the speediest atom of uranium.

A radio wave will move from Chicago to New York in a little less than one two-hundredth of a second, which is less time than it takes you to hear a revolver shot fired within a foot of your ear. This same radio wave will pass along the length of a usual one-hundred-foot antenna in about one ten-millionth of a second. If it arrives at right angles to the antenna wire, the time which it has to influence the electrons in the wire is still shorter, probably substantially less than a billionth of a second.

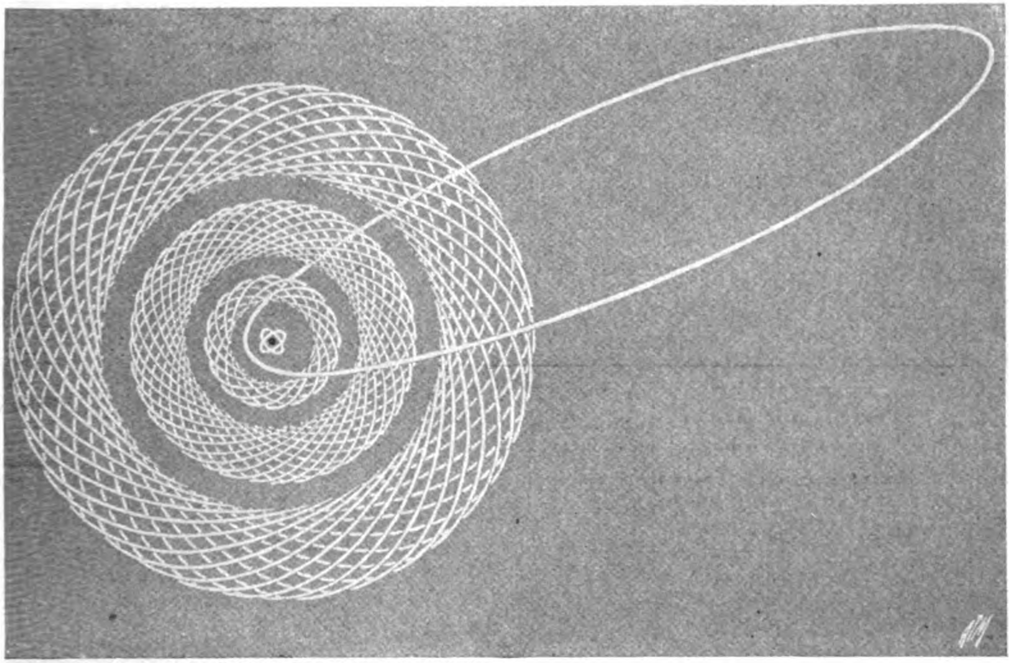
Like all the other figures which one rattles off glibly when atoms or ether waves are under discussion, these statements mean nothing whatsoever to the average human mind. They must be visualized by comparison. The time occupied by a rifle bullet in leaving the gun barrel when a gun is fired is usually about one five-hundredth of a second. This is two hundred thousand times longer than the time which a radio wave takes to pass along the length of an antenna. While the bullet is leaving the gun there is time for as many back-and-forth reflections of a radio wave (or of a light beam) in a one-hundred-foot antenna as there are individual letters of printed type in this issue of POPULAR RADIO.

But, short as is the time which a radio wave spends thus in dalliance with your antenna, the times of the atomic rotations are far shorter still. Each of the atoms of copper in an antenna wire possesses 29 planetary electrons. The speediest of these electrons moves with a velocity of about 40,000 miles a second; the slowest has a speed of a little less than 10,000 miles a second. The times



HOW ELECTRONS PRODUCE ETHER WAVES

The white curves represent some of the orbits which may be occupied, in turn, by the single electron of an atom of hydrogen. Ordinarily, the electron revolves, with tremendous speed, in one or the other of these orbits. Under some circumstances, however, it may jump from one orbit to the other, as is indicated by the black lines. Such a jump sends out a pulse of ether energy in the form of light.



From a drawing made for POPULAR RADIO by Arthur Merrick

AN ATOMIC PICTURE OF A SILVER DOLLAR

This diagram gives a rough idea of the structure of an atom of metallic silver. Each of the white curves represents the normal orbit of one electron. In all, there are 47 of them. One of the orbits extends much farther out from the center of the atom than do the others, and this fact is responsible for some of the peculiar chemical properties of silver. The actual atom is much more complicated than this simplified diagram.

needed for one revolution are, respectively, about one five-sextillionth of a second, for the fastest electron, and about sixteen times as long for the slowest electron. Again, the figures so transcend human experience that they mean nothing. Let us compare them, however, with the time needed by the radio wave to pass the antenna.

This time, we have just seen, is about one ten-millionth of a second. It is one two-hundred-thousandth of the time which a bullet needs to be fired out of a gun. Yet this short interval is over three hundred million times longer than the revolution time of even the slowest of the electrons in the copper atom. While a radio wave is passing once along the length of an ordinary antenna each of the electrons in the copper atoms will revolve from three hundred million times to over five thousand million times, depending upon whether one considers the slowest of the electrons or the fastest of them.

Let us put this conception, also into more familiar images. Imagine a vast line of airplanes arranged, one behind the other, in a field. Imagine the propellers of all of them spinning at the rate of six thousand revolutions a minute, which is quite fast even for an airplane propeller, easily fast enough to lift the plane off the ground. But the planes are imagined held down somehow, each propeller spinning. Let these typify the spinning atoms of copper in the antenna wire.

Now let us imagine a projectile of some sort fired past all these spinning propellers, or through them, to represent the moving radio wave which comes along and traverses the antenna. How fast will this projectile have to move to bear the same speed-relation to the revolving propellers that the radio wave bears to the fast revolving atoms?

The answer is a surprise. The speed of this projectile need not be more than *one third of an inch a day*. The slowest snail would be bored were he compelled to travel no more rapidly. Even molasses in January flows faster than this.

In fact, then, radio waves are not so fast after all, when they are compared with the astounding number of revolutions made by the electrons in the atoms. This does not mean, of course, that the speeding electron actually moves through space faster than the radio wave does. That, we have said, is probably impossible. What happens is that the atomic orbits are so small that the radio wave is in the substance of the antenna long enough for a vast number of individual atomic rotations to occur; a number which could be represented, with any adequacy at all, only by enough airplanes to fill the whole earth.

The practical point is that the speed of radio waves and the speeds of atomic rotation belong to the same order; they are parts of the same time-universe, the universe whose proper unit is a billionth of a second or less, instead of the day-unit or the year-unit which we find more convenient. As science progresses in the study of the interaction between ether waves, and the atoms and electrons of matter we shall have to devote more and more attention to this inconceivably rapid and short-timed universe where billionths of a second are long.

This interaction of matter and radiation constitutes the greatest present-day problem of physics. If ether waves did not affect the atoms of matter at all we would have no way of knowing that such waves exist, for we ourselves are composed of matter. Light is an example. A fire consists of a vast assemblage of atoms in trouble. Because of intense chemical reaction or perhaps merely because of heat, these atoms are losing and gaining electrons very rapidly. Such electronic shifts produce ether waves of light. These waves fly off with their tremendous speed of 186,000 miles a second and come, some of them, into a human eye. Here they meet atoms, the atoms of the retina. They do something to these atoms. No one knows just what they do but many scientists now believe that they cause the emission of electrons from these atoms, just as light rays do in the photoelectric cells now coming into use in the radio transmission of pictures. Whatever happens in the retina, the ultimate result is an electric message to the brain. The owner of the eye sees light.

There is involved, you perceive, a succession of interactions between the atoms in the fire, the ether waves and the atoms in the eye. Similarly, the longer radio waves affect in some manner the electrons in wires, so that radio reception becomes possible. All these interactions, so vital to almost everything in the universe, occur in very tiny spaces, spaces belonging to the size-scale of the atoms. They occur, too, in very tiny times, times of the order of billionths of a second or less. In the time while a silver dollar is falling from your work table to the floor whole lifetimes of atomic changes may have come and gone.

"Master-Lessons" Broadcast to 1,000,000 School Children

"AMONG our 25,000,000 school children in the United States, there are probably 1,000,000 who are studying approximately the same subject at the same time. Were there a radio set in every school, it would be possible to broadcast master-lessons in various subjects which would be rich in suggestion. . . . Geography could be made an adventure by introducing frequent talks by men and women who had recently visited areas which the children were studying. . . . Every state school system should investigate the possibilities of using this new tool—probably the greatest contribution to the advancement of popular intelligence since the invention of movable type at the middle of the 15th Century."

—JOY ELMER MORGAN

¶ Are you tempted to join the army of 17,000 transmitting amateurs? If so, this article will tell you how to do it

From a photograph made for POPULAR RADIO

HOW TO LEARN THE CODE

The man in the picture is sending himself code letters on a buzzer which he hears in the headphones. This is one good way to practice the receiving speed required for an operator's license.

HOW TO GET

An Operator's "Ticket"

What you must know about radio to pass the Government's First-grade Operator's examination—and how you can prepare for it

By HOWARD S. PYLE

THE embryo amateur, enthusiastic over the prospect of actually owning and operating radio equipment for talking back to those he hears, is of two classes.

Foremost are those who enter any project in which they become interested with a whole-souled enthusiasm that closely approaches foolhardiness. These rush madly into the amateur game and purchase many dollars worth of transmitting equipment, and after confidently assembling it, they write a letter, or call in person at the office of the Supervisor of Radio for their district and request "a license, please!" And here they meet their first brick wall, for no amount of battering will break down the necessary formalities of obtaining a license to operate their equipment.

The second class of enthusiasts about to enter the amateur field are those who proceed cautiously and methodically in any project which they undertake. They discover almost immediately, generally through conversation with some local amateur, that Uncle Sam *insists* on a demonstration of their telegraphing ability before the dreaded Omnigraph, or "infernal machine" as it is often called. He will also inquire further into their knowledge of radio through the medium of a comprehensive written examination. Our seeker for an amateur license then, will as his next step, endeavor to gain some information on what to study and on just what points to prepare himself for such an examination. And here he meets *his* brick wall!

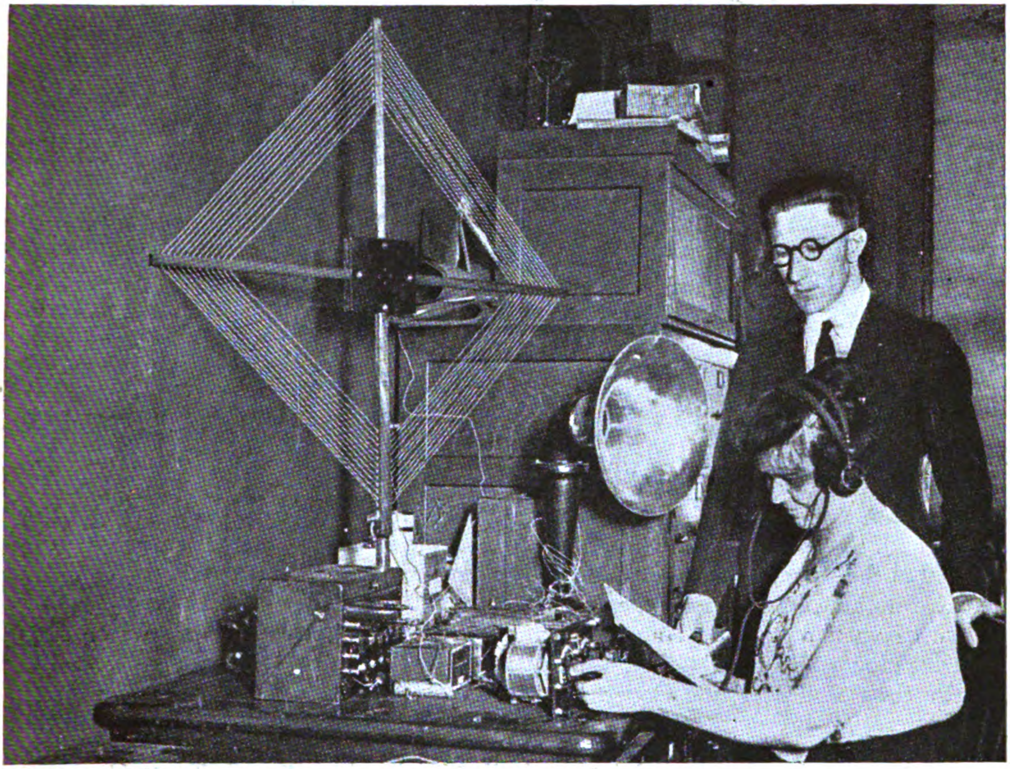
Obviously, the question sheets of the Department of Commerce are not public property in the sense that they are not promiscuously distributed to those who express a desire for them. On the contrary, they are carefully guarded in the Radio Supervisors' offices. There is, of course, no objection to the general gist of such papers being known, for it serves as a guide to enable concentration of effort along the proper lines, to a prospective applicant. For instance, it would be extremely foolish for a student to laboriously master the fundamentals and circuits of arc transmitting equipment in preparation for an examination where such material would be foreign. But nevertheless, an intelligent and helpful guide to preparedness for the amateur examination is practically impossible to secure.

This article tells the requirements for the amateur, first grade, radio operator's license.

The Department of Commerce, in drawing up the examination questions, had certain points in mind. Foremost, of course, was the ability of the applicant to use the telegraph code. Obviously, it would be useless, as well as actually dangerous, to issue a license to a man who had an excellent theoretical knowledge of radio communication, but who could not distinguish the characters of the International telegraphic code. He could cause untold damage by operating his equipment in times of distress, thus causing interference with important communication. A vessel in grave peril, sending an SOS, would be greatly hampered in securing aid or might even sink in the event that her distress signals were so interfered with as to prevent their reception ashore. It was therefore decided that amateur radio operators must be familiar with the Continental code to the extent that they could recognize distress signals sent slowly and repeated a number of times.

An arbitrary speed of five words a minute was originally agreed on as sufficient, but experience proved it to be too slow. The rate was accordingly increased to ten words a minute, counting five letters, numerals or other characters to the word. An applicant is really offered five opportunities to demonstrate his ability to translate signals at this speed. Straight, readable matter, containing no numerals or punctuation is sent him during a five minute period. He is required to copy but ten consecutive words (fifty letters) to secure a passing grade, from the fifty words (250 letters) sent him. It is assumed, however, that he will put down a reasonable portion of the balance, in addition to the required number.

Up until a few years ago, no attention had been paid to an operator's ability to *transmit* the code characters. It was assumed that anyone capable of receiving the code, could satisfactorily transmit, for mastering the handling of the key is popularly supposed to be extremely simple. Large numbers of operators, notably at sea, were later found, on observation, to have extremely poor "fists" as their sending hand and style is termed in radio phraseology. Some really good operators fell into the rut and developed what they were pleased to call, "individual style" in their sending. Oldtimers will recognize this as what is often referred to as the "Lake Erie Swing" on the Great Lakes and by similar descriptive names on the coasts.



Underwood & Underwood

A RADIO "COP" CHECKS UP ON RADIO "PIRATES"

If an amateur operates without a license or "jumps" his wavelength, a Federal inspector will catch him with the direction-finding apparatus shown in the picture.

It is true that practically all experienced operators have some individualism in their sending, but it has come with experience, naturally; not through misspent effort to develop a radical style. It does not necessarily mean that the formation of the characters is impaired; rather, it is often an improvement on the mechanical sending of automatic devices which reproduce the characters precisely and automatically.

This practice of purposely chopping up the dots and dashes, as well as lack of training in sending, led the Department of Commerce to inaugurate a transmission test, and now all radio inspection offices are equipped with keys and buzzers, as well as tape recorders, and an applicant must show up equally well in his transmitting ability as in his receiving speed.

It is required, in the case of amateur applicants, that they transmit fifty well formed characters (ten words) consecutively, without error, from a group of two hundred and fifty letters (fifty words) supplied them for copy. A speed of ten words a minute must be maintained throughout. A tape record of their transmission, as well as a copy of their receiving test, is filed with their application as part of their record.

Before you appear for your examination, you should be able to copy from 13 to 15 words a minute under ideal conditions, that is, from your own set at home with no interference, either extraneous noise or radio interference. You are bound to lose your ability slightly, due to a natural nervousness, when you appear for examination. The same applies to your transmission, although not as a rule in the matter of speed. Formation of your characters has a great deal to do with your success, and you should therefore devote much of your time to proper spacing of letters and words, rather than to acquiring great speed; that will come with practice. Learn to grasp your key firmly, and eliminate the tendency to nerve-sending, by allowing your entire forearm to rest on the table.

The majority of amateurs use vacuum-tube transmitters and oscillating receivers. The forms are wide and varied, but the underlying principles and the theory of operation are identical. But to just the same extent do they differ from commercial types of transmitters; marine and shore stations. The theory involved is the same, but beyond that the two have nothing in common unless it be the use of vacuum tubes. Naturally, in appearing for your examination, for an amateur class of license, the Government is not interested in what you may know of commercial installations. It wants to be assured that you know enough about *your own* equipment to handle it intelligently, and to determine this point, the entire series of questions is based on your own transmitter; not on one you've seen on a steamer or in a broadcast station, but the one that is actually *on your own operating table!*

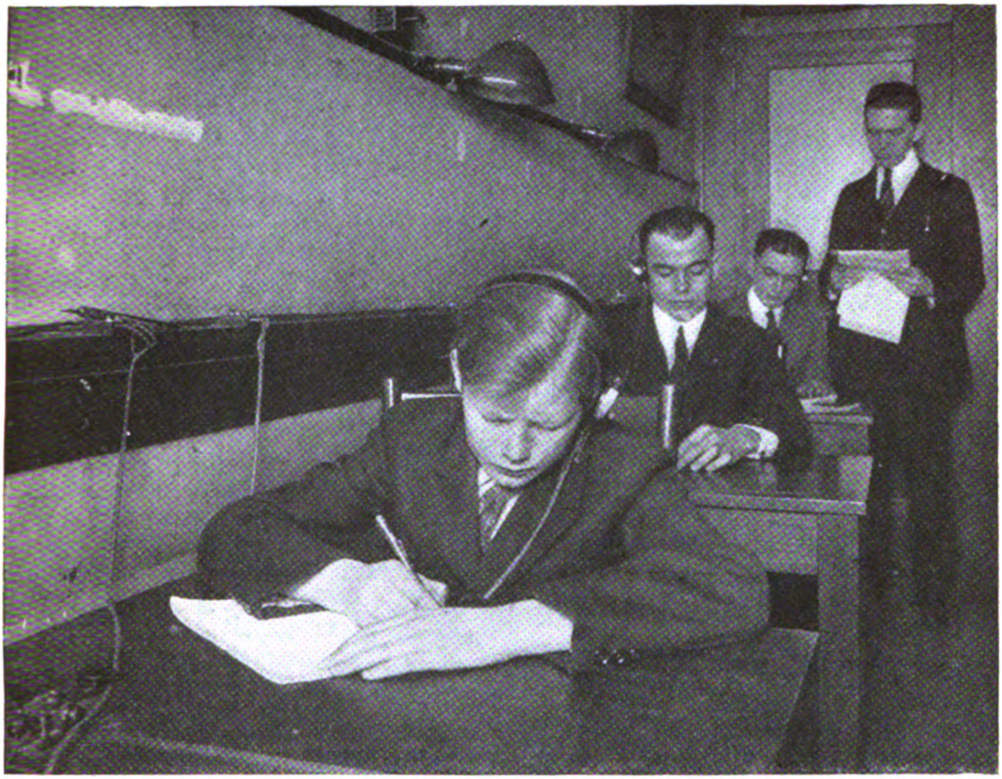
You can hold an operator's license even if you own no transmitter, but in this event, you are required to answer your questions covering the transmitter you *propose* to operate, which may be that of a friend, or one you are now building. The first point in connection with your station which will demonstrate your knowledge of your apparatus, is the method in which it is connected. Just like your more advanced brother, you are required to show a complete diagram of the transmitter, receiver, antenna and source of power. This must be *complete* in every sense of the word; each part being properly named and a brief description of its use lettered *on the diagram!* The examiner can therefore tell by a glance at your first sheet, about your fundamental knowledge of radio circuits.

A brief and sketchy description such as you are permitted to make on the diagram to illustrate the *use* of each device, does not mean that you understand its theory and functioning. In order to determine this, the Government will ask you for a complete description of the operation of your transmitter and receiver. This does not mean that you are to say, "I throw my antenna switch to the transmitting position; cut in my power and work my key." What is wanted is something like this:

"Using the alternating current of the house lighting circuits, through the medium of a step-down transformer, the filament of the vacuum-tube oscillator is brought to incandescence, thus emitting an electronic stream, which is caused to flow to the plate by reason—"

Carry out this description through your entire transmitter and receiver, explaining how oscillations are generated, how controlled and how the circuits are tuned. Do *not* be too brief, for you will be marked in exact accord with knowledge your answers show.

An extremely important requirement of the Federal law is that your transmitting wavelength be maintained within proper limits. General amateurs are at present allotted the wavelengths between 150 and 200 meters for regular use, and if your apparatus has a coupled antenna circuit and is capable of producing what is known as a pure continuous wave unmodulated by voice, buzzer, chopper, commutator ripple or alternating current hum, you can request permission to operate on either 75 to 80 meters, 40 to 43 meters, 20 to 22 meters or 4 to 5 meters. It may be readily seen that is it therefore important that you know how to measure your emitted wave, as well as what apparatus is used to effect such a measurement. You will be questioned on these points, and it is best to gain a rather comprehensive knowledge of these measurements before you



From a photograph made for POPULAR RADIO

"BRASS POUNDERS" TAKING THE GOVERNMENT TEST

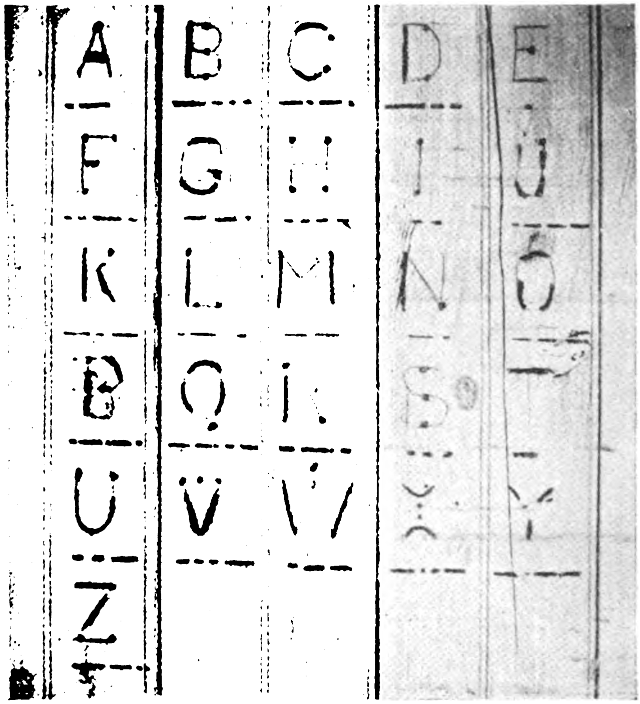
Besides answering technical questions about transmitting, receiving and radio auxiliary apparatus, the "ham" must take down Morse Continental code messages. An examiner in an adjoining room sends the dots and dashes which the license applicant hears in the headphone he wears.

appear before the Federal examiners.

While a knowledge of the Federal wavelength requirements and methods of measurements is essential, there are a number of other laws bearing both directly and indirectly on amateur stations that are extremely important. A good bit of your examination will be based on the essentials of such legislation. Let us consider then, the high lights in the present radio communication laws, where they affect amateur stations and operators.

When you are issued your station license, the Supervisor of Radio will include with it a small card bearing extracts from the law regarding the secrecy of messages and false signalling, with the penalties therefor. You should familiarize yourself with these provisions so that no little detail escapes you.

You will find that *no* message, regardless of its contents or its apparent surface harmlessness, may be divulged other than to the person to whom addressed; a station engaged in relaying such communication, or to a court of competent jurisdiction. Of course, as in all things, there are exceptions. If the message bears the address: "To all ships and stations" as Government weather reports generally do, then the information is meant to be public property. The signal "QST" (meaning, "General call to all stations") has the same meaning, and such information may also be safely dispensed. But *be sure* that the address clearly indicates the message to be public



From a photograph made for POPULAR RADIO

HOW TO LEARN THE CODE IN PICTURES

One amateur memorized the code by painting it on the wall of his bedroom. Each letter in the picture is built up of heavy dots and dashes which are the outline of a particular letter. "A" for instance is dot dash. The dot is at the top of the "A" and the dash is the line that connects the two legs of the letter. Below each letter is the code symbol for the letter. "S," for example, has three dots.

property; otherwise you are subject to a rather heavy fine or imprisonment! Familiarize yourself with these penalties as well as the provisions of the paragraph. False signalling—fraudulent distress calls and similar matter are *extremely serious offenses*. The fine and imprisonment for violation are particularly severe. Be sure that you know this law as well.

You will find, specified in your station license, a clause to the effect that you can use power "—not to exceed one (or one half) kilowatt input." This means that if you are in the general amateur class, which means five or more nautical miles from a military or naval station, that your maximum power consumption in the plate circuit of your transmitter must not exceed one thousand watts. Should you be within the restricted class (or five mile circle) this is reduced to five hundred watts. However, this is specified as the *maximum* power allowed you for *any* communication. It will be found by reference to the communication regulations, that you are required to use the least amount of power to cover the required distance. In other words, if your transmitter has a normal full power range of five hundred miles, you are violating the law if you use such power for local communication. It must be reduced to the least amount necessary to insure the reliable exchange of signals. If every telegraphing amateur followed the law, much interference would be eliminated.

The present radio communication laws were drawn up twelve years ago. They have been amended since, but they are still essentially the same. This is true of both our own laws and the draft of the London Convention, which regulates practically all of the radio activities of the world.

At the time such legislation was enacted, there were few stations, and fewer trained operators. In order to provide the operators with sufficient "practice" to keep them in form, as well as to enable instruction of new men, practice "over the air" was permitted where it did not interfere with other radio communication. Twelve years ago this was easily possible. The law remains the same today, but the effect is entirely different, for there are probably but a scattered few places on the earth where practice carried on in the air would not cause interference with some other station. At any rate, within the territorial limits of the United States, it is safe to say that to follow the strict letter of the law means that practice is really prohibited. The same holds true for superfluous signals and "service talk."

The rest of the "exam" is based on the Radio Communication Laws of the United States and on the International Radio-telegraphic Convention. Complete drafts of both documents will be found in the book entitled "Radio Communication Laws of the United States," which may be obstained from the Superintendent of Documents, Government Printing Office, Washington, D. C., at a cost of fifteen cents in currency, (stamps are not accepted). The writer cannot urge too strongly that every prospective amateur secure a copy of this publication and become thoroughly versed in the paragraphs bearing on amateur equipment. There are not many, and it is not necessary to memorize the wording; but satisfy yourself that you have a good understanding of the meat in each paragraph. In addition, learn the abbreviations commonly known as the "Q" signals, which can be obtained from almost any radio book. They will also be found in the rear of the Government publication above mentioned.

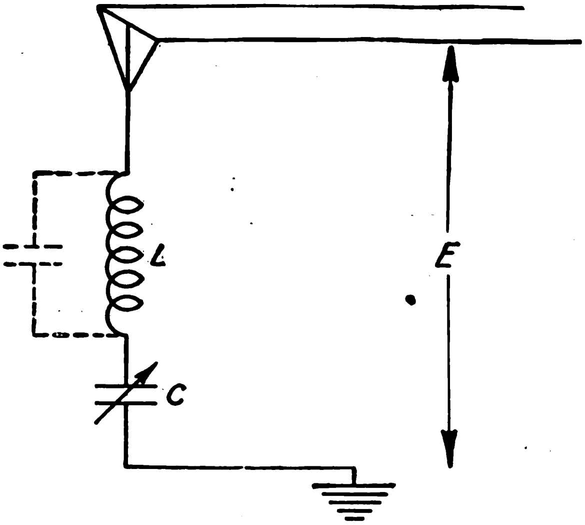
Examinations for the amateur grade of radio operator license are held on regular schedules in the various radio inspection offices throughout the country. Usually each supervisor has a special day set aside for this purpose. In the Eighth District, with headquarters at Detroit, Michigan, for example, "Amateur Day" is Saturday. The examinations are usually scheduled for 10.00 A.M. and it is wise to appear promptly at that time, for the examining officer dislikes to be compelled to run the code test again for late-comers. Should you not be located convenient to one of the district offices, and a fixed day would thereby inconvenience you, a special appointmen can generally be made. Communicate with your supervisor in this respect. To those who are really remote from an inspection office, a temporary permit, in the form of an amateur's second grade license may be issued, upon receipt of answers to a questionnaire accompanied by an affidavit attesting your code ability. The holders of such temporary permits are then required to appear for personal examination when a Radio Inspector conducts such tests in your district.

The amateur game is one of the most satisfying and productive hobbies available. To young men and boys it opens a field for experimentation that cannot be equalled in any other art. It has an excellent influence on a growing boy and tends to keep him from the companionship of questionable characters. Today amateurs are counted in six figures.

Let the aspiring applicants to the "blue ticket" of the full-fledged amateur be encouraged and may the great fraternity remain foremost among the country's youthful experimenters!

" Fifteen Ways to Reduce Static "

—will appear in the next issue of Popular Radio*—for May*



AN ORDINARY TUNED ANTENNA CIRCUIT

FIGURE 1: *This is an example of a tuned circuit which has the voltage introduced in a part of the circuit exterior to the coil. Broadcast receivers generally make use of an untuned antenna circuit.*

What a Straight-line Frequency Condenser Really Is

If you want to know all that goes into the production of a condenser with true straight-line-frequency characteristics, what value a low minimum capacity has—or has not—and what straight-line-frequency really means, read this article by—

HERBERT J. HARRIES

IT isn't so very long ago that the "sacred angle" of the coils in the neutrodyne was the principal subject of discussion whenever two or more dyed-in-the-wool radio enthusiasts met at luncheon. At any rate, each was certain that he had the right "dope" on the exact number of degrees, and tenths of a degree, necessary to make the thing "neut" properly.

But now the sacred angle is forgotten and the straight-line-frequency condenser has become the favorite topic. Opinions concerning its virtues, and vices, seem to be nearly as much at variance as those concerning the proper angle for neutrodyne coils.

One gathers, from what one hears, and reads, that the straight-line-frequency condenser—

(a) is the perfect panacea for all the ills to which a radio set may be subject, not excluding de-thoriated filaments and exhausted "B" batteries;
(b) is "all the bunk," and a darned clever idea to sell more condensers to an unsuspecting public;
(c) theoretically cannot be designed but in practice can be approximated by a cut-and-try process;
(d) can be designed with mathematical exactness and manufactured with any reasonable degree of precision.

Presumably in all these contradictions

there are some whole truths, some half-truths and some un-truths. At any rate, manufacturers are making and selling something they *call* straight-line-frequency condensers.

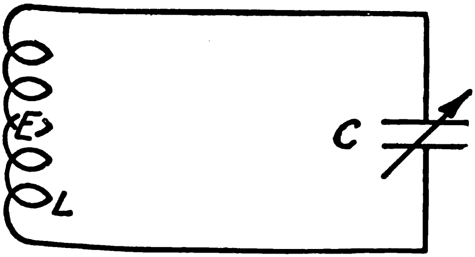
At this point a pertinent question is: *What* and *why* is a straight-line-frequency condenser?

Taking up first the *why* part of this question, we must consider some regulations made by the Department of Commerce.

In the early days of radio communication it was customary to say that a station transmitted on a certain wavelength. This usage was continued when broadcasting was inaugurated, and even to this day stations are listed according to their wavelengths. However, it has been found that wavelength is an inconvenient standard and it is being replaced by another standard, the frequency.

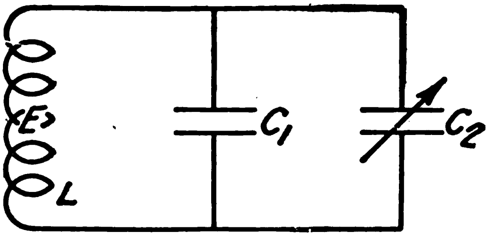
The reason for this is that, to prevent interference between stations, it is necessary to separate them according to a definite rule. This works out in such a manner that KYW (536 meters) must transmit about ten meters below KSD (546 meters) to prevent interference, whereas the separation between WJJD (303 meters) and WPG (300 meters) need be only a third as much for satisfactory transmission. As we go farther down the meter scale the required separation becomes less.

Experiment has shown that if the frequencies of the transmitting stations differ by exactly ten kilocycles no interference is experienced. Consequently, the Department of Commerce has allocated frequency bands to the broadcasting stations. KSD is permitted to use the band between 545 and 555 kilocycles and the frequency of its carrier wave is maintained at 550 kilocycles. KYW is required to maintain its carrier wave at a frequency of 560 kilocycles, just ten kilocycles higher. In a like manner WJJD uses a frequency of 990 kilocycles and WPG uses ten kilocycles more, or 1,000 kilocycles. Thus, it is seen that at every ten kilocycle division along the broadcasting frequency range there is a broadcasting station.



THE MOST COMMONLY USED TUNING CIRCUIT

FIGURE 2: *In this common circuit of the radio receiver the voltage (represented by E) is induced in the coil itself. The coil L will have some distributed capacity.*



A CIRCUIT EQUIVALENT TO THAT OF FIGURE 2

FIGURE 3: *In this circuit L is a pure inductance and its distributed capacity is represented as C1. C2 is the tuning condenser.*

The *what* part of this question now is clear. We wish to have all these stations distributed uniformly over our dials so we use condensers in which the plates are shaped so as to give that uniform distribution. In other words, we wish to get uniform separation of *frequencies*, rather than uniform separation of wavelengths. As a matter of fact, the term wavelength, used in connection with broadcasting stations, is obsolete, and the sooner it is dropped the better.

The next question is: Is it possible to design and manufacture condensers which will give to the circuit in which they are used a perfectly straight-line-frequency tuning characteristic; that is, perfectly uniform separation of the stations on the dials, or are there reasons why such a design is theoretically or commercially impossible and which make it necessary to accept a design only approximately giving the desired characteristic?

It is not necessary to have an elaborately equipped laboratory at one's service to investigate this question, for it is simply a matter of effecting a compromise between a mathematically perfect design and one which is commercially acceptable. Therefore, let us look into it first from the purely mathematical viewpoint, and then from the commercial viewpoint.

As a preliminary measure let us recall some of the facts we know concerning coils and tuned circuits.

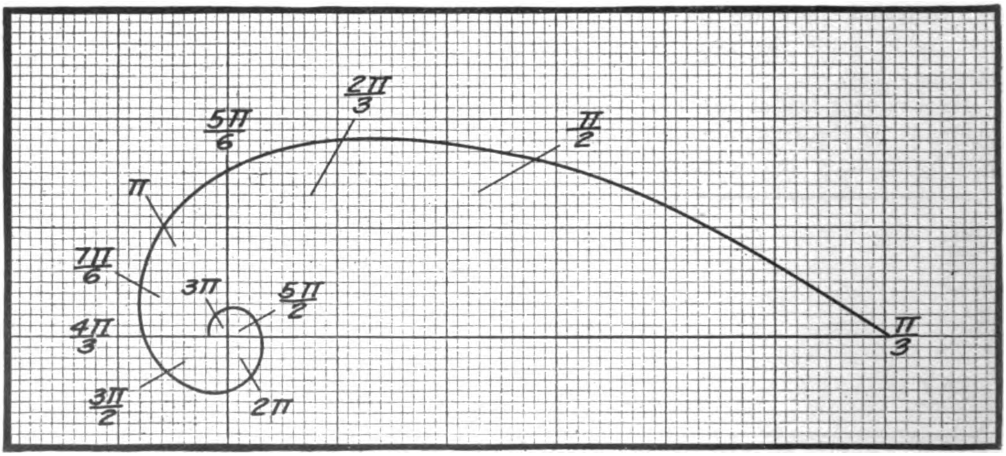
In the first place, we know that a coil has two values of inductance, its *pure* inductance, and its *apparent* inductance. If it were possible to wind coils that had no distributed capacity we should have only the pure inductance to consider. But every coil has some distributed capacity, and under certain conditions that capacity leads us to think the inductance is more than it really is. We call this *observed* value the *apparent* inductance.

Also, we use two kinds of tuned circuits. In one the voltage is induced somewhere in the circuit exterior to the coil. An example is the antenna circuit of Figure 1.

The coil L is in series with the variable condenser C and the source of voltage E. In the other the voltage is induced in the coil itself. An example of this type of circuit is the usual tuned circuit shown in Figure 2 where the voltage is induced within the coil as indicated.

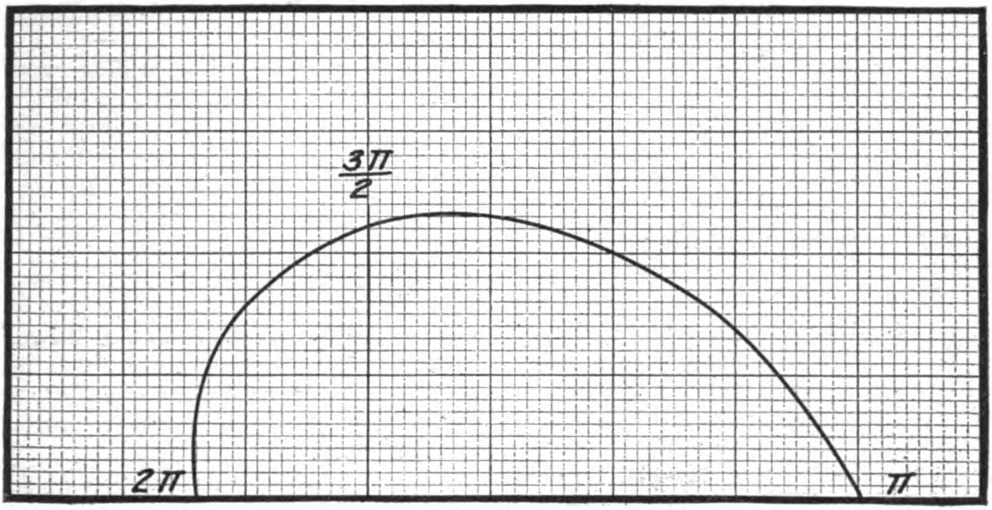
When considering the circuit of Figure 1 it is somewhat simpler to calculate the change in the apparent inductance with the frequency, according to a formula available for that purpose, and use those values in circuit calculations. This is because the coil and its distributed capacity, shown as a dotted condenser in Figure 1, are in series with the variable condenser. When considering the circuit of Figure 2, it is simpler to disregard the apparent inductance entirely. The capacity of the coil is in parallel with the capacity of the variable condenser, so we use the constant value of the pure inductance and add the coil capacity to the condenser capacity to determine the total capacity in the circuit. The equivalent circuit is shown in Figure 3 where L is the constant pure inductance, C_1 the constant distributed capacity of the coil, and C_2 the adjustable capacity of the condenser.

The circuit of Figure 1 is of comparatively little interest to the builder of broadcast receiving sets, since an untuned antenna circuit is in almost universal use.



THE HYPERBOLIC SPIRAL THAT DETERMINES THE SHAPE OF THE PLATES

FIGURE 4: *Such a curve gives the outline of the plates for a straight-line-frequency condenser. A section of this curve which gives a variation in capacity proportional to the frequency range to be covered is chosen.*



A SECTION OF THE HYPERBOLIC SPIRAL

FIGURE 5: *This section of the original curve is correct for tuning in stations that have a 2:1 frequency ratio. That is, it would tune in a series of stations between 500 and 1,000 kilocycles or any other series whose maximum to minimum frequency has the ratio of 2:1.*

So we may confine our study to the circuit of Figure 3.

The frequency to which this circuit is resonant; that is, the frequency at which the reactance of the coil becomes equal and opposite to the reactance of the condenser, and thus neutralizes it, is given by the formula

$$f^2 = \frac{159200^2}{L\,(C_1 + C_2)}$$

Hence, knowing the frequency of any station desired, and the inductance and distributed capacity of the coil, we can calculate the value C_2 must have to tune that station in.

An important point which we must not overlook is that we are not interested in what value of the inductance or capacity of the coil may be, nor in the manner in which the capacity of the condenser varies as the dial is turned. What we are interested in is the result of the combination of those factors; that is, we are interested only in the frequency to which the circuit becomes resonant as the dial is turned.

It is evident, therefore, that in designing a condenser to give the circuit a straight-line-frequency tuning characteristic we must consider, in order, the frequency range we wish to cover, the inductance of the coil we wish to use, and the distributed capacity of that coil.

The problem confronting the condenser manufacturer, therefore, is that of providing a condenser wherein the capacity varies in such a manner that it will tune the circuit to a range or frequencies uniformly distributed over the dial. For example, if the desired frequency range is 500 to 1,500 kilocycles, the condenser capacity should be proportioned so that, using a coil of given inductance and distributed capacity, a 600 kilocycle station will tune in at 10, a 700 kilocycle station at 20, a 1,000 kilocycle station at 50, and so on.

The exact manner in which the condenser capacity varies to accomplish this is not of interest. The only consideration of interest is the variation in the *resonant frequency of the circuit* as the condenser dial is turned.

Neglecting the coil capacity for the moment, and considering the total capacity of the circuit to be concentrated in the condenser, it is apparent that it must vary inversely as the square of the frequency, that is, the outline of the plates must be a hyperbolic spiral. Such a spiral is illustrated in Figure 4.

It is evident we can select a portion of this curve which will give us a variation in capacity proportional to any frequency range we wish to cover. This brings up another consideration, the *frequency ratio,* which is simply the ratio of the highest frequency to which we wish to tune to the lowest.

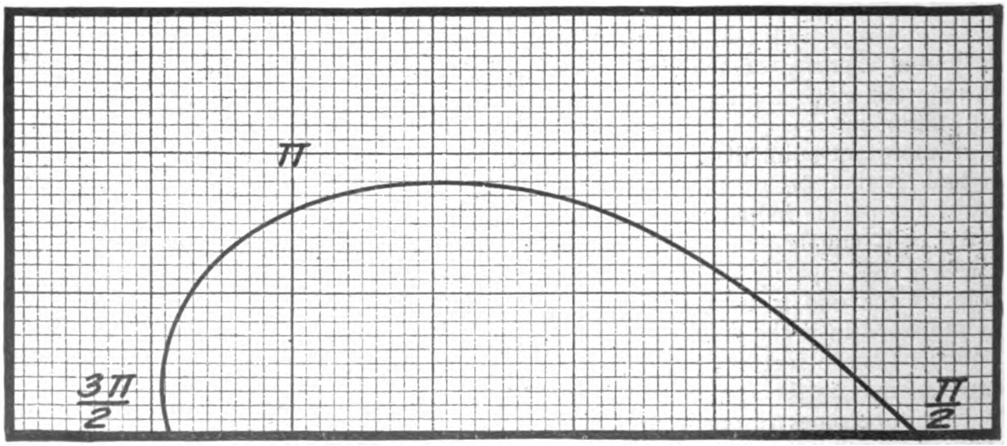
For the range 500 to 1,000 kilocycles, a ratio of 2:1, we would use that part of the curve proportional to that ratio, that is, the portion included between π and 2π, as in Figure 5. For the range 500 to 1,500 kilocycles, a ratio of 3:1, we would use that portion included between $\pi/2$ and $3\pi/2$, as in Figure 6 For the range 500 to 2,000 kilocycles, a ratio of 4:1, we would use that portion included between $\pi/3$ and $4\pi/3$, as in Figure 7. If we wished to cover a very narrow range, such has 500 to 600 kilocycles, a ratio of only 6:5, our plates would be very nearly circular and we would use that portion between 5π and 6π, as in Figure 8.

It is apparent, by this time, that the factor which determines the curvature of the plates, is the frequency ratio. Also, the curvature is different for different ratios, if we do not want the stations concentrated on fifty to seventy-five percent of our dials.

Plates shaped according to these curves would give the circuit a perfectly straight-line-frequency tuning characteristic over the desired frequency range if the coil had no distributed capacity. To compensate for the capacity of the coil, it is necessary to modify the outline of the plates so that, in the final design, the variation in condenser capacity is not in inverse proportion to the square of the frequency. It is such, however, that the variation in the total *circuit capacity* is inversely proportional to the square of the frequency.

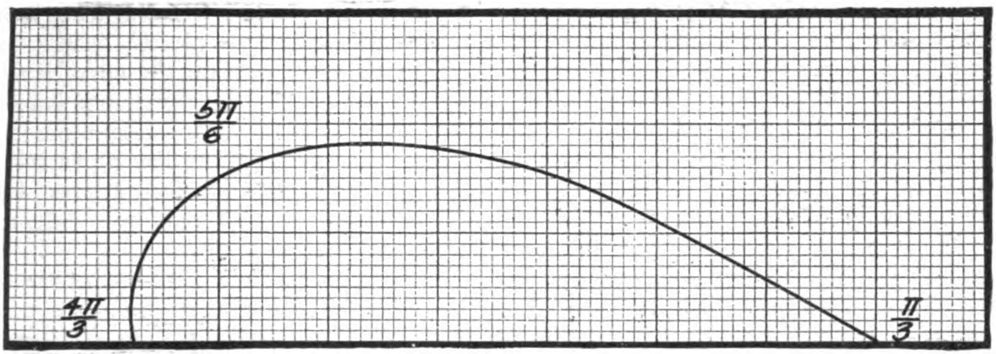
We can consider this question of design from a different angle by considering the circuit of Figure 3. Using the formula given previously it is a simple matter to calculate what values C_2 must have at any setting of the dial to give the circuit a straight-line-frequency tuning characteristic when used in conjunction with a coil.

Suppose, for example, we decide we wish to cover the range 500 to 1,500 kilocycles. Let us assume that the minimum capacity of the condenser is 15 mmfd., which is a fair value, and that the distributed capacity of the coil is 10 mmfd. Then the minimum capacity of the cir-



THE SECTION OF THE SPIRAL FOR BROADCAST FREQUENCIES

FIGURE 6: *This section of the curve gives the plate shape for obtaining a 3:1 frequency ratio. It would tune in stations having frequencies between 500 and 1,500 kilocycles, which is approximately the broadcast range.*



A SECTION FOR COVERING A WIDE FREQUENCY RANGE

Figure 7: *This section of the curve has been selected to cover a 4:1 frequency ratio. Plates of this shape would spread a band of stations between 500 and 2,000 kilocycles uniformly over the tuning dial.*

cuit is 25 mmfd. and the inductance required to tune to 1,500 kilocycles is

$$L = \frac{159200^2}{f^2_c\,(C_1+C_2)} = \frac{159200^2}{1500^2 \times 25} = 451 \text{ microhenries.}$$

Using this value of inductance we find that to tune to 500 kilocycles

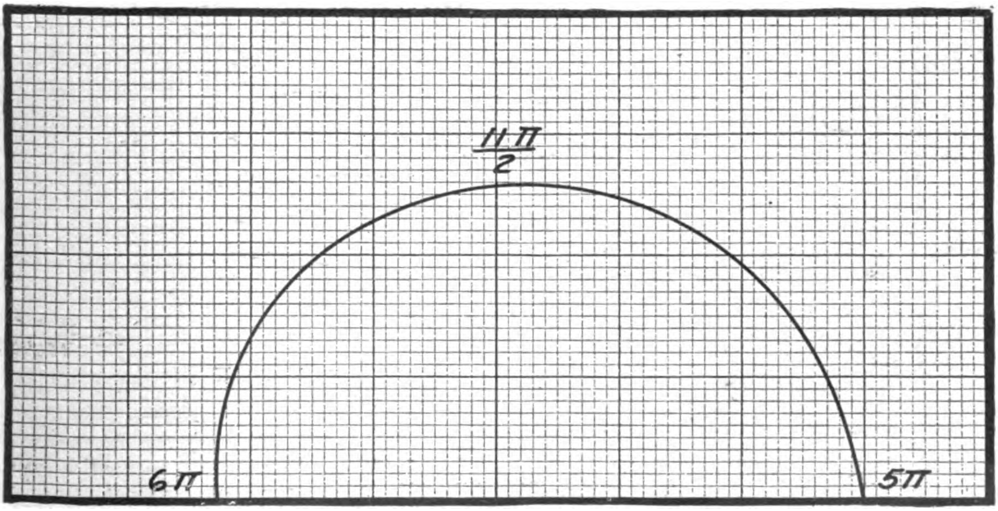
$$(C_1 + C_2) + \frac{159200^2}{f^2\,L} = \frac{159200^2}{500^2 \times 451} + 225 \text{ mmfd.}$$

and $C_2 = 225 - 10 = 215$ mmfd.

We could determine the maximum capacity required in the circuit in another way. The required *capacity ratio* equals the square of the desired *frequency ratio*. We wish to cover a 3:1 frequency ratio so the required capacity ratio is 9:1, that is, the maximum capacity required in the circuit is $9 \times 25 = 225$ mmfd.

Consequently, with a coil of 451 microhenries inductance and 10 mmfd. distributed capacity, and a variable condenser of 215 mmfd. maximum capacity and 15 mmfd. minimum capacity we can cover the desired frequency range, but only under certain conditions.

The formula we have employed presumes an ideal condition, and the pres-



A SECTION OF THE SPIRAL FOR A NARROW FREQUENCY BAND

Figure 8: *This section of the curve shows the plate shape for covering a 6:5 frequency ratio. A condenser of this type would place stations between 500 and 600 kilocycles a uniform distance apart on the tuning dial.*

ence of other apparatus may bring about other than that ideal condition. For example, a primary coil coupled rather closely to our secondary would cause a considerable reduction in our frequency range and we should find it necessary to increase the inductance of the coil and the capacity of the condenser.

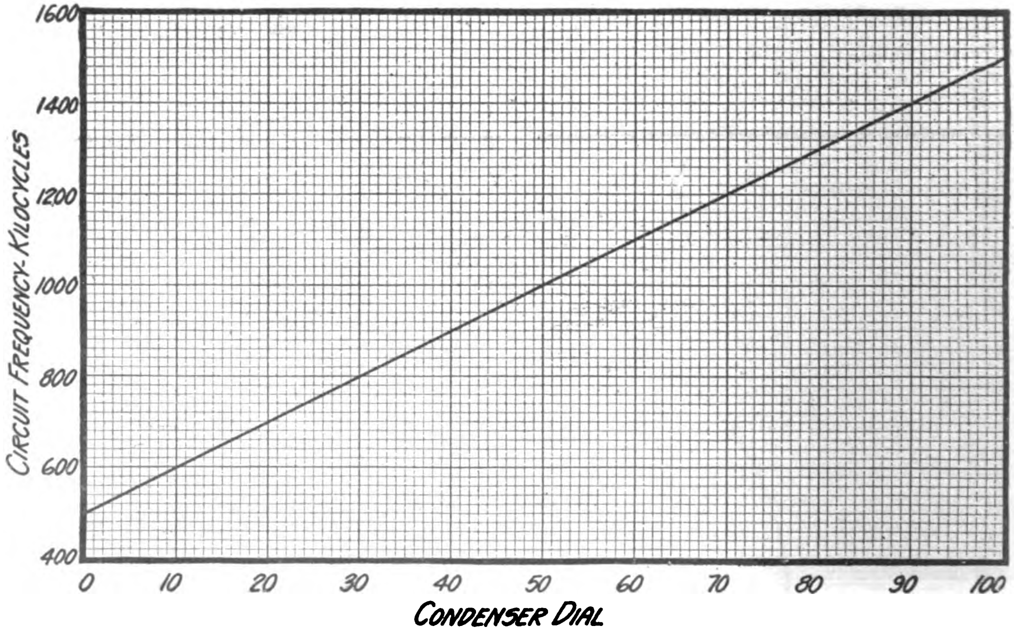
However, we may consider that our coil is a loop excited directly by the broadcast wave and thus consider that the ideal condition exists without affecting the validity of whatever conclusion we may reach.

If our condenser is calibrated into one hundred divisions, the relation of frequency to dial setting is as shown in Figure 9 and it becomes a simple matter to calculate the capacity needed in the circuit at every tenth division, say, to obtain this straight-line-frequency tuning characteristic.

If we plot $(C_1 + C_2)$ against the frequency on logarithmic co-ordinates, as in Figure 10, we find that we get a perfectly straight line, that is, the change in *circuit capacity* is a straight-line-frequency variation. But when we plot C_2 against the frequency also, we find the curve is not a straight line, that is, the change in condenser capacity is not a straight-line-frequency variation. What law of variation it actually follows is of no interest, but the variation is different for different frequency ratios.

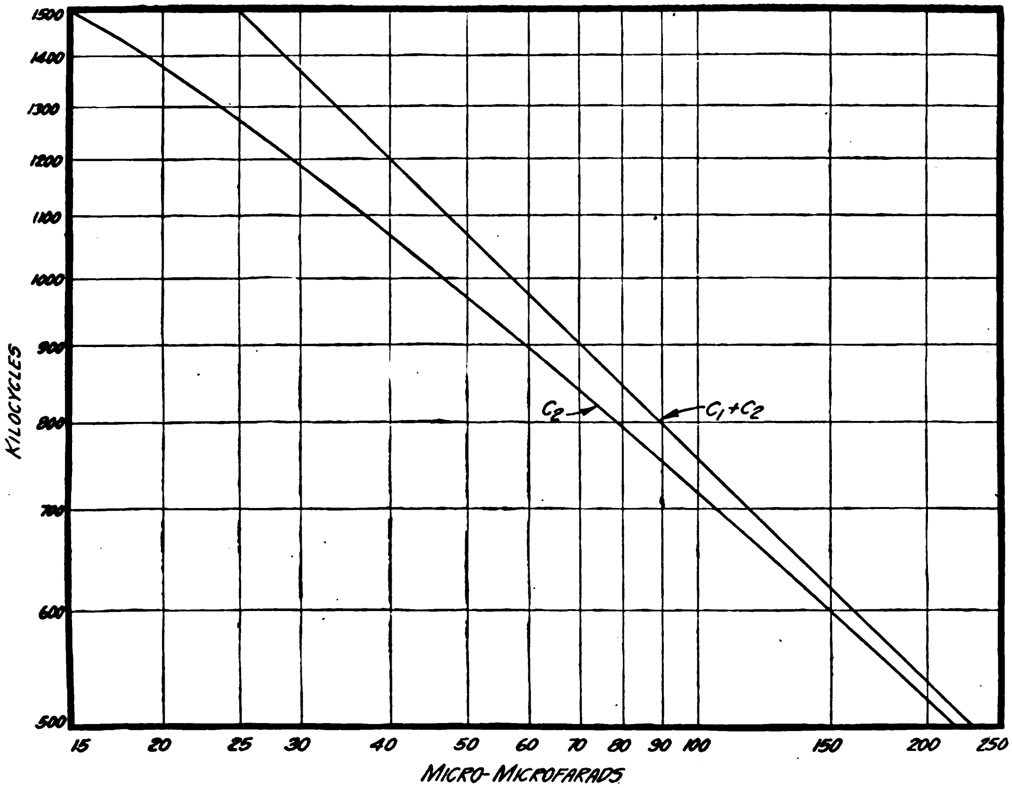
Now let us consider what happens when we attempt to use this condenser over another frequency range with a different frequency ratio. Suppose we wish to cover one of the amateur ranges, 1,500 to 2,000 kilocycles, say, a frequency ratio of 4:3. A little calculation shows that we must use not less than 254 microhenries inductance and further calculation gives us values which, when plotted, give us curve A of Figure 11.

We see that the straight-line-frequency tuning characteristic of the circuit is not impaired, but the frequency range we wished to cover is crowded into the upper thirty-eight divisions of the dial, as indicated by the solid portion of the curve.



THE STRAIGHT-LINE-FREQUENCY TUNING CURVE

FIGURE 9: *This chart shows the curve for a tuned circuit which has the correct capacity to spread the frequency bands uniformly over the one hundred divisions of the condenser dial.*



THE CAPACITY-FREQUENCY CURVE

Figure 10: *The total circuit capacity (C1 + C2) has a straight line variation with frequency when plotted on logarithmic paper. But when the distributed capacity of the coil C1 is subtracted from the total circuit capacity we find that the desired tuning capacity C2 does not have a straight line variation with the frequency.*

If we go to the other extreme and use the largest inductance that will permit us to tune to 1,500 kilocycles we get curve B of Figure 11. The straight-line-tuning characteristic of the circuit still is unimpaired but the dial is crowded worse than before and the frequency range we wish to cover is concentrated into only seventeen divisions.

By using any value of inductance between the minimum and the maximum we can place the solid portion of the calibration curve on any sector of the dial we wish, and, depending upon the value of the inductance used, it will include some number of divisions between seventeen and thirty-eight, which represent the maximum and minimum condition of crowding for this particular frequency range.

Also, these curves bring out a fact which is true of any type of condenser but which is sometimes overlooked. That is, the frequency ratio cannot be greater than the square root of the circuit-capacity ratio, assuming a constant value of inductance. In the cases we have been considering the circuit-capacity ratio was 9:1 and the frequency ratio in each case was 3:1 as can be seen by referring to Figure 9 and Figure 11.

Since no tuned circuit is complete without a coil, it seems that we are led logically to the following conclusion:

> *A condenser intended to afford the circuit in which it is used a straight-line-frequency tuning characteristic, with the stations within the desired frequency range spread*

over the whole of the dial, should be designed for a pre-determined frequency ratio, and for use with a coil of known inductance and known distributed capacity.

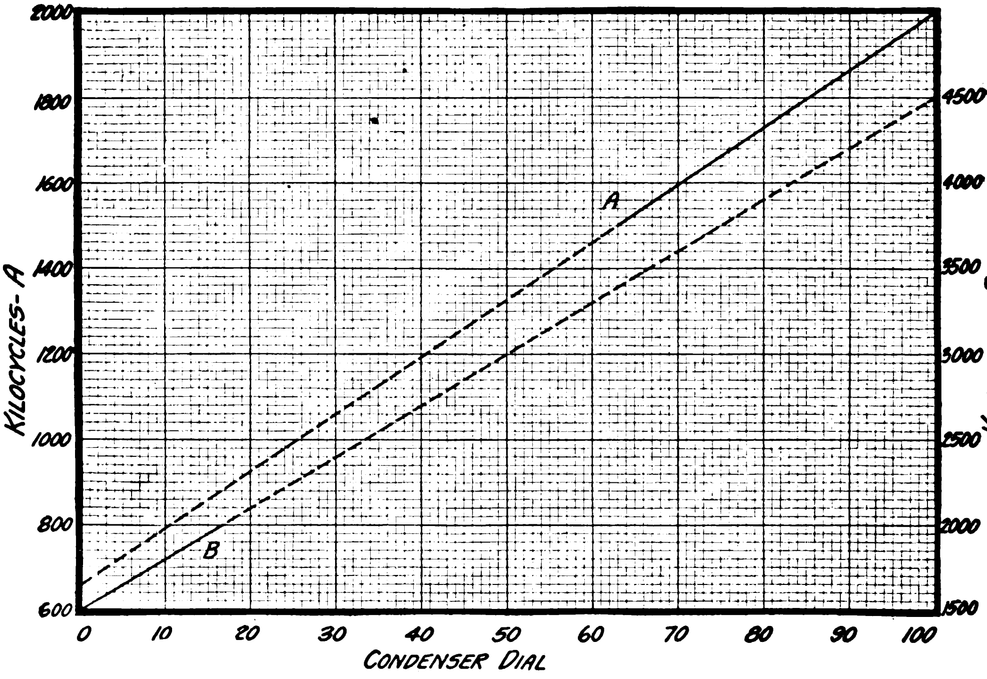
So far we have considered this question only from the mathematically perfect viewpoint. Now let us look at it from the commercial point of view, not forgetting that commercial considerations frequently are just as important, and sometimes more so, than mathematical perfection.

As a manufacturing proposition the 215 mmfd. condenser we have been considering is well within commercial limitations, for 15 mmfd. is a reasonable minimum value. There is no reason why we cannot design dies with which we can punch out plates that will conform to curve C_2 of Figure 10 within very close limits. When used with the coil we considered the tuning characteristic of the circuit would be a perfectly straight line so far as we could determine with any instruments ordinarily available.

The next question is: Would this condenser be satisfactory for use with coils of more, or less, distributed capacity? Upon investigating this phase of the matter for coils of 5 and 15 mmfd. distributed capacity we get the curves of Figure 12.

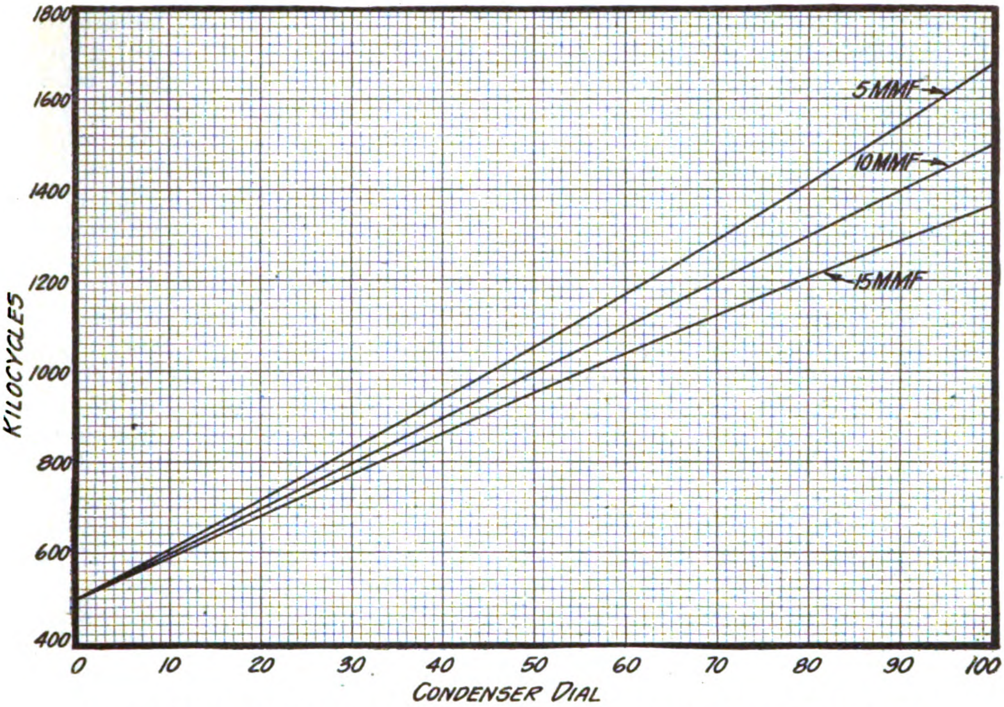
It is plain to be seen that neither the 5 mmfd. nor the 15 mmfd. curve is a straight line. However, the degree of curvature is comparatively slight, and, for all practical purposes, each may be considered to be straight. We may conclude, therefore, that a fifty percent increase, or decrease, in the distributed capacity of the coil does not impair the straight-line-tuning characteristic of the circuit to any material extent.

We should not overlook the fact that



THE RESULT OF USING A 3:1 FREQUENCY RATIO CONDENSER ON A NARROW FREQUENCY BAND

FIGURE 11: *Curve A shows the result when the condenser is used on a 1,500 to 2,000 kilocycle band with minimum inductance to cover this range while curve B shows what happens when the condenser is used with maximum inductance to cover this band. The dotted lines represent the unused parts of the dials.*



THE RESULT OF VARYING THE DISTRIBUTED CAPACITY OF THE COIL

FIGURE 12: *The central curve is for a condenser designed to give straight-line-frequency tuning when used with a coil having a distributed capacity of 10 micro-microfarads. A coil having 5 micro-microfarads capacity will extend the frequency range, while one having 15 micro-microfarads will limit it below the range desired.*

the frequency range changes with a change in coil capacity. In the case of the 5 mmfd. curve the minimum frequency is 505 and the maximum 1,675 kilocycles. In the case of the 15 mmfd. curve the minimum is 495 and the maximum only 1,370 kilocycles. Thus the reduction in coil capacity crowds seventeen percent more stations on the dial, whereas the increase in the coil capacity reduces thhe number of stations by twelve percent.

It is apparent that a condenser of this size would be inadequate to cover the frequency range if the upper broadcasting limit should be raised to 2,000 kilocycles. In that event, the smallest condenser that could be used would have a maximum capacity of somewhere near 375 mmfd. Also, a different portion of the hyperbolic curve would be used to determine the curvature of the plates.

The next consideration of interest is in connection with the design of a 500 mmfd. condenser where we encounter a problem that differs from any we have considered yet.

Let us figure on covering the same frequency range as before, 500 to 1,500 kilocycles. If the maximum condenser capacity is 500 mmfd. and the coil capacity is 10 mmfd., the maximum circuit capacity is 510 mmfd. and the minimum circuit capacity required is one-ninth of this or 57 mmfd. Subtracting the coil capacity, the minimum capacity required in the condenser is 47 mmfd. Also, the required inductance is 200 microhenries.

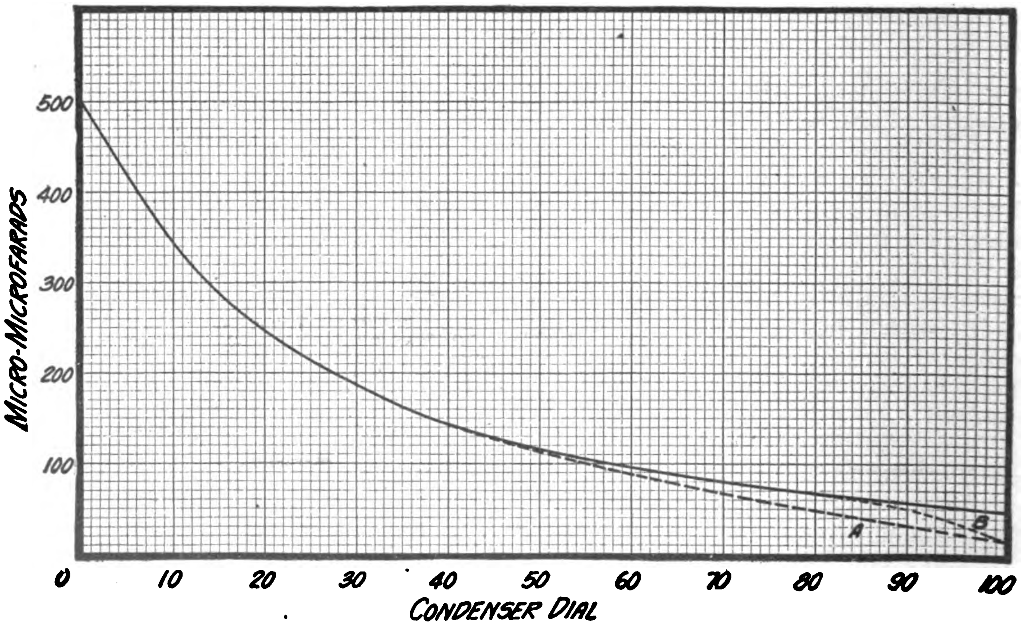
From these values we can calculate the required condenser capacity at each tenth dial division and obtain the solid capacity curve of Figure 13. We note that the minimum condenser capacity is very high, some three or four times the minimum usually found in condensers of this size. If we wish we can build condensers with this high minimum which will afford the solid calibration curve of Figure 14. But if we consider it necessary to cater to the demand for a very low minimum capacity we can modify the curvature of the plates so as to give the capacity curve shown at A in Figure 13, or at B, as we prefer.

If we decide to use curve A, then our calibration curve changes as shown at A in Figure 14, and we find we have rendered twenty percent of the dial useless. If we decide to be conservative and only modify the plates a little so as to correspond with capacity curve B (Figure 13), the calibration curve becomes that at B in Figure 14 and only ten percent of the dial is unused.

The reason for this change in the calibration curve, of course, lies in the fact that the capacity ratio no longer equals the square of the frequency ratio by which the curvature of the plates was determined. Whereas the outline of the plates was such as to correspond to a frequency ratio of 3:1, or a capacity ratio of 9:1, the actual capacity ratio has become (500 + 10) / (15 + 10) or about 20:1. The corresponding frequency ratio is approximately 4.5 ÷ 1, which is the *only* frequency ratio for which a condenser with these maximum and minimum capacities can be designed to give the straight-line-tuning curve shown at D in Figure 14 if we wish to use the whole of the dial range.

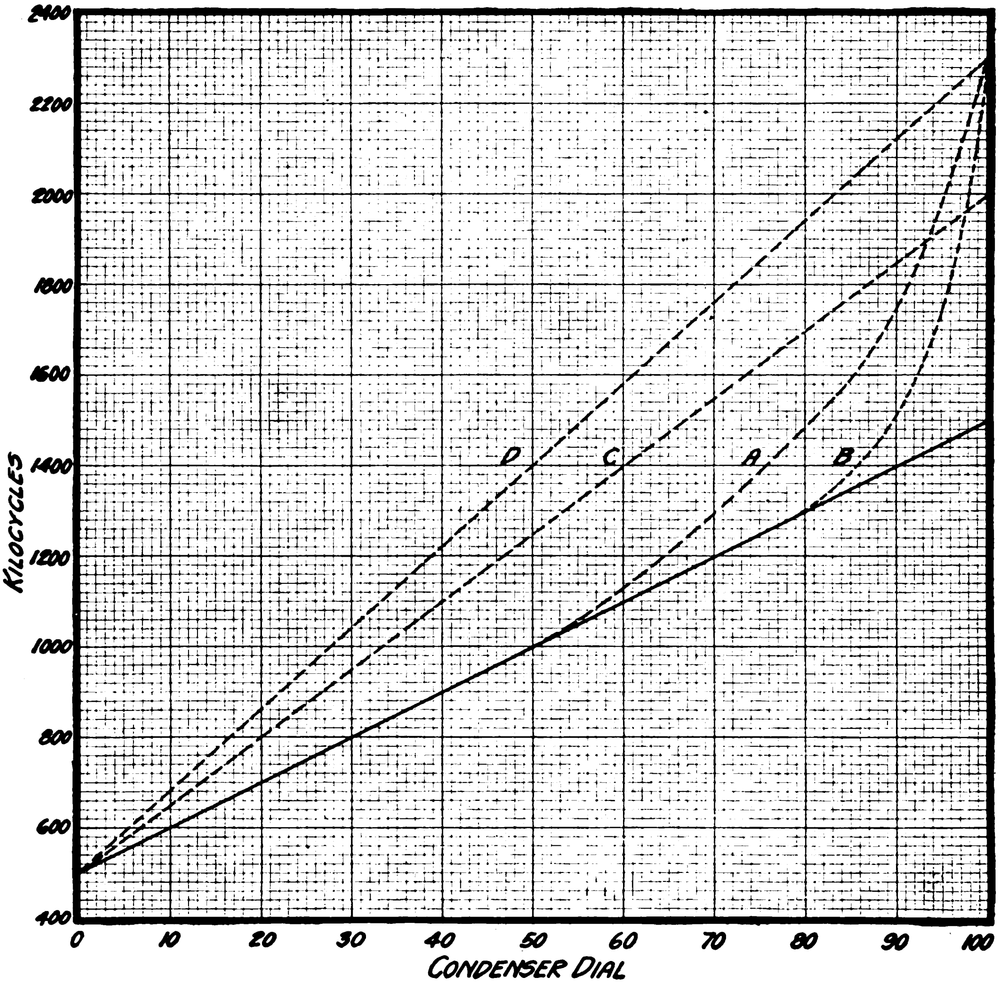
Should the upper limit of the broadcasting frequency range be raised to 2,000 kilocycles, it is apparent that a 500 mmfd. condenser modified according to either curve A or curve B would cover the complete frequency range, but the calibration curve would be far from straight and the stations between 1,500 and 2,000 kilocycles would be badly crowded. It would be necessary to shape the plates according to that portion of the hyperbolic spiral (Figure 7) included between $\pi/3$ and $4\pi/3$ to give the straight-line-tuning curve shown at C in Figure 14.

Incidentally, another bad effect of low-



THE CAPACITY CURVES FOR A 500 MICRO-MICROFARAD CONDENSER

FIGURE 13: *The solid line is a curve for a straight-line-frequency condenser having a 3:1 frequency ratio. Note the relatively high minimum capacity. Curves A and B show methods of modifying the capacity curve to get a low minimum, but they only use 80 and 90 percent of the dial respectively.*



THE TUNING CURVES FOR THE CONDENSERS OF FIGURE 13

Figure 14: *The curves A and B show that the capacity curves cover a much greater frequency ratio than 3:1 and that they are no longer straight-line-frequency curves when they are modified to obtain a low minimum capacity. Curve D is the only straight-line frequency variation between the maximum and the modified minimum.*

ering the minimum capacity in this manner is that the resistance of the condenser at the low capacity settings is increased an astonishing amount over what it would be with a high minimum capacity.

In conclusion, then, it seems that the frequency ratio is the principal factor to be considered in determining the proper curvature of the plates, that the distributed capacity of the coil may vary within reasonable limits without affecting the straight-line-tuning characteristic of the circuit to a serious extent, but that it may reduce the frequency range considerably, and that the inductance of the coil has no effect upon the straightness of tuning curve but determines to what extent the stations desired are crowded into a small sector of the dial. Also, it would appear that the general practice of catering to the demand for a very low minimum condenser capacity serves no useful purpose and is a detriment in that it distorts the tuning curve and increases the condenser resistance at low capacity settings.

Kadel & Herbert

WHERE THE WATCH IS KEPT

Hour after hour during the long broadcasting programs this operator listens in for the call of distress that may come at any moment from the sea.

"S. O. S."

What Happens When a Call for Help Is Picked Up During Broadcasting Hours

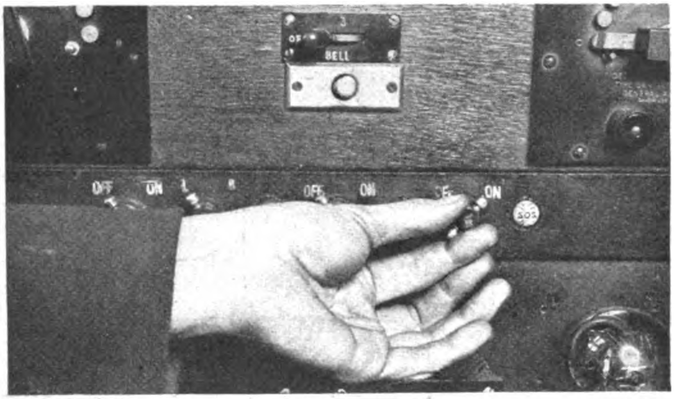
WHEN you hear a sudden "Signing off, account of an S.O.S." come from your loudspeaker in the midst of a program and then find that every other broadcaster has suddenly become silent, what is really happening behind the scenes?

In every broadcasting station there is a receiving set which is constantly tuned to 600 meters. At most stations an operator keeps constant watch for the "S.O.S." call, which means that a ship is in distress and that human lives are in danger.

The moment the listener hears that call he signals to the control room of the station to stop broadcasting. The ether must be cleared at once; there must be no chance that the ship's cry for help may be interfered with.

In the control room, as the listener signals, a tiny light on the panel in front of the operator flashes its warning that an "S.O.S." has been received. In a moment he throws over a switch on the panel which halts all transmission.

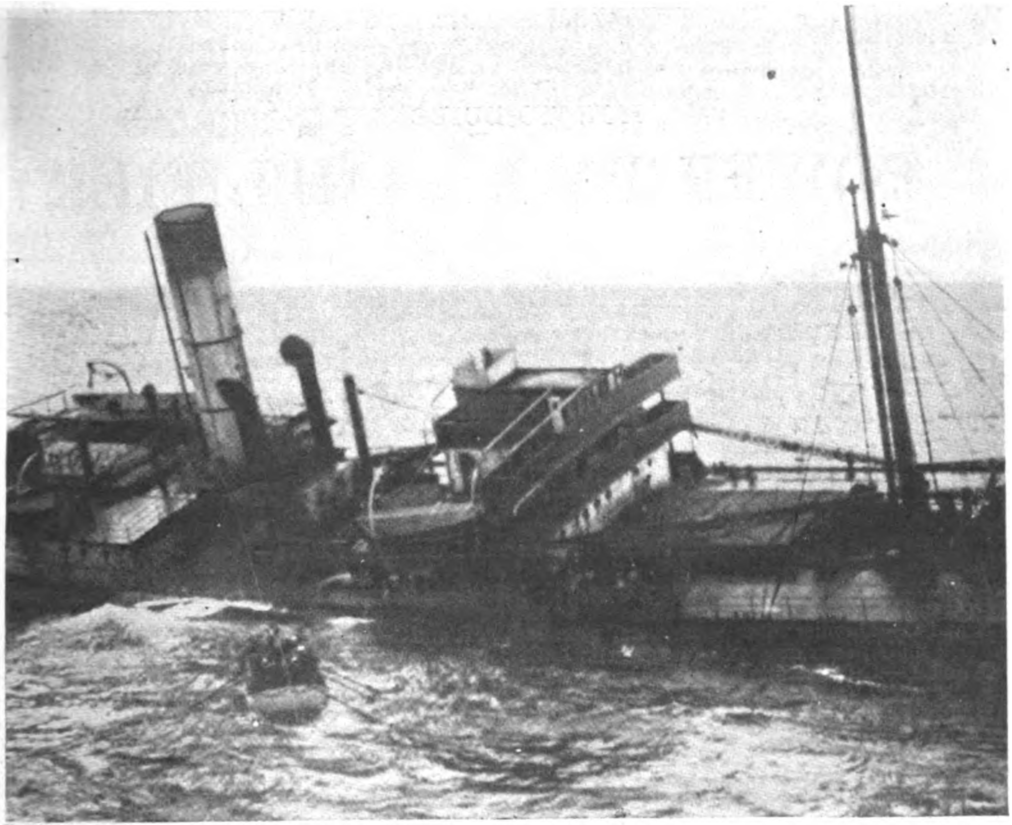
In this way the program is immediately cut off and there is complete silence until the ship's message has gone through to those who can bring aid.



Kadel & Herbert

THE OPERATOR CUTS OFF THE PROGRAM

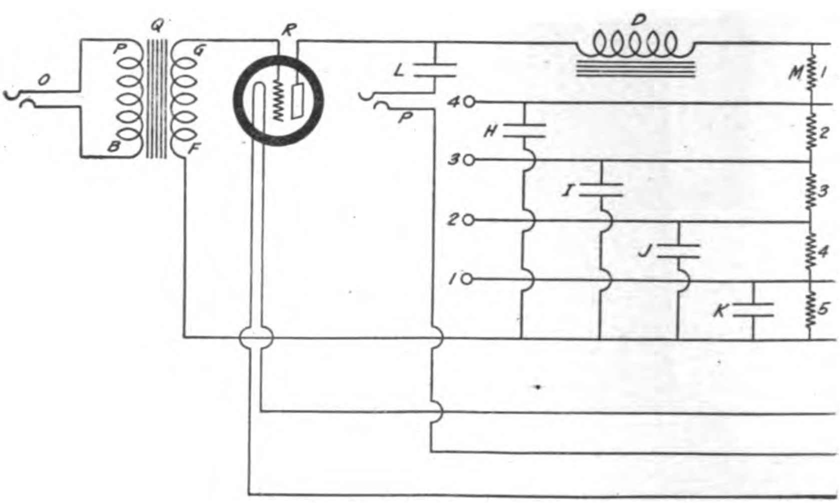
When the tiny light at the right of the panel flashes a warning, the control room operator knows that an "S. O. S." call has been heard by the listener-in and he calls "signing off, account of an S. O. S." and cuts off all transmissions until he knows that the distress call has been heard and answered.



Kadel & Herbert

WHEN THE "S. O. S." CALL IS ANSWERED

Rescue scenes such as this are the rewards of the silent listeners for the fateful call signal. In this instance the entire crew of the Italian freighter "Ignacio Florio" was saved by the crew of the "President Harding," as a result of the vigilance of the little company of men who always sit at the radio receivers—listening.



THE COMPLETE THEORETICAL CIRCUIT DIAGRAM

FIGURE 1: *The hook-up for the "Power-pack" amplifier and "B" current unit. All the symbols for the instruments bear designating letters which are used consistently in the list of parts, text and illustrations.*

HOW TO BUILD THE

POWER-PACK AMPLIFIER

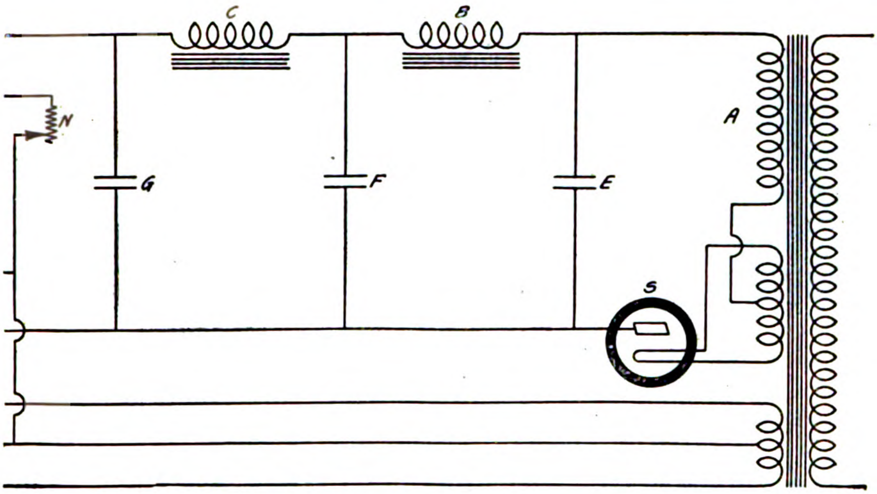
This new unit gives to experimenters and radio fans for the first time a reliable power amplifier that uses a high voltage on a power tube and a plate-supply unit for any radio set that it may be used with. It will give reproduction of a large orchestra with the same quality and strength as that produced by the orchestra itself. It supplies the "A," "B" and "C" voltages to the high power amplification in the last stage direct from the alternating current lighting lines.

By ALBERT G. CRAIG

COST OF PARTS: Not more than $94.00

THE PARTS USED IN THE LABORATORY UNIT—

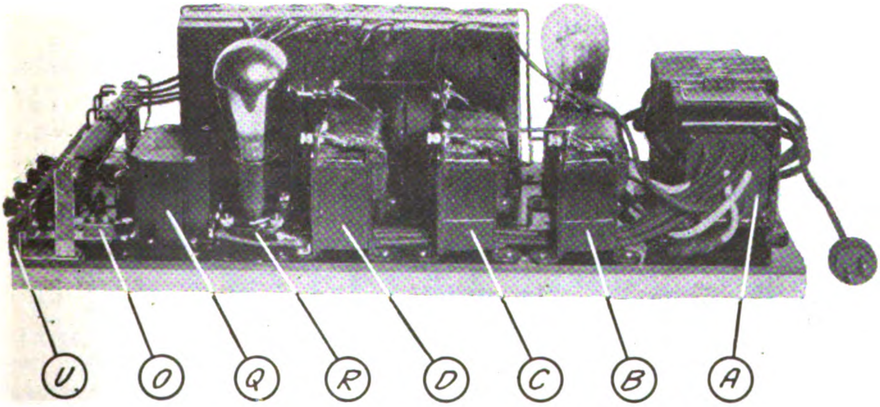
A—Amertran power transformer, type PF-52;
B, C and D—Amerchokes, type 854;
E and G—Dubilier filter condensers, type 769, 2 mfds., (working voltage 400 volts D.C.);
F and L—Dubilier filter condensers, type 770, 4 mfds., (working voltage 400 volts D.C.);
H, I, J and K—Dubilier filter condensers, type 766, 2 mfds., (working voltage 160 volts D.C.);
M—Ward Leonard vitrohm resistor unit, size C or Aerovox Craig resistor, type 980—
Both of these resistance units are tapped as follows: step 1—12000 ohms; step 2—3500 ohms; step 3—1500 ohms; step 4—1500 ohms; step 5—750 ohms.
N—Bradleyohm No. 25, 25,000 to 250,000 ohms;
O and P—Pacent single-circuit jacks, No. 61;
Q—Amertran De Luxe audio-frequency transformer for second stage;
R and S—Benjamin push type sockets, No. 9040;
T—bakelite sub-base, 7 inches by 21 inches by ¼-inch;
U—bakelite binding post strip, 7 inches by 1 inch by ¼-inch;
V—angle brass reinforcement strips for sub-base; (see Figure 6);
W—angle brass for holding binding post strip; (see Figure 6);
X—brass brackets for mounting resistor unit M, (see Figure 6);
Note—These brackets are not required for the Aerovox Craig resistor;
Y—brass strip for mounting filter condensers; (see Figure 6).



For the benefit of our readers in any locality, in the United States or abroad, who are unable to obtain parts that are necessary to make up these model receivers, the POPULAR RADIO SERVICE BUREAU *will undertake to supply the desired parts and have them forwarded C. O. D. If any reader cannot obtain any necessary part from his local dealer, he may send in his order to the* POPULAR RADIO SERVICE BUREAU, *627 West 43rd Street, New York, which will have it filled for him and thus help him to obtain parts as promptly as possible.*

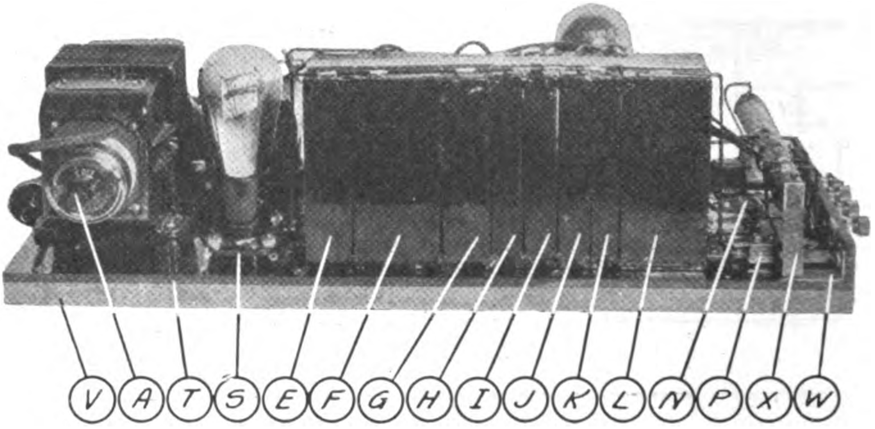
THE first demand of the listener in after the novelty of radio reception has worn off is for a better quality of reproduction. But this desire for good tone quality with reasonable volume has rarely been gratified, largely because of the ease with which the last audio-frequency amplifying tube is overloaded in most present-day receivers.

To remedy this condition and to supply either large or small volume with excellent quality this power amplifier has been designed. The "power-pack" amplifier described in this article uses the UX-210, one of the new power tubes which have recently been placed on the market for the purpose of transmitting a much larger amount of energy to the



A REAR VIEW OF THE DEVICE

FIGURE 2: *This illustration shows the general location of the transformer, tubes, chokes, condensers and resistances.*



A FRONT VIEW OF THE UNIT

Figure 3: *The bank of condensers, the rectifier tube and the power transformer with its "on" and "off" switch that also gives three power ranges are shown here.*

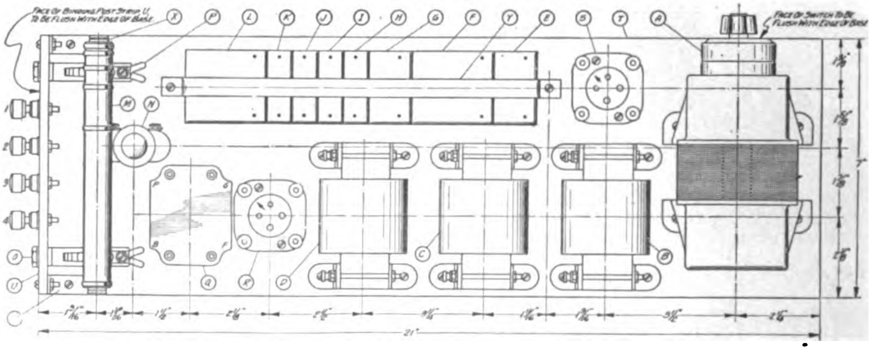
loudspeaker without distortion; and it operates directly from the 110-volt alternating current lighting mains.

This power tube uses several hundred volts on the plate; and this makes the cost of "B" batteries prohibitive. Consequently a plate or "B" current supply has been incorporated in the power unit to furnish this high voltage.

In addition, the plate current supply has been designed to furnish "B" current at several lower voltages for all of the other tubes in the receiver which is used with this unit. This entirely eliminates the "B" batteries.

The apparatus available for the construction of "B" eliminators has improved very much in the last year. All of the parts which are used in this power supply, such as the transformer, the rectifying tube, the choke coils and the resistor will handle a direct current output of 60 milliamperes without overload; and the condensers will stand a direct current working voltage of 400. This is quite an advance over the use of 201-a tubes for rectifiers and of audio-frequency transformers for choke coils.

The use of a stage of power amplification on the dry-cell set is worthy of special mention. Ordinarily the dry-cell set will not handle great volume with good quality because of the limitations of the last tube. Now, in practically every case, all of the tubes, except the last audio amplifier, are functioning nor-


FACE OF BINDING POST STRIP U TO BE FLUSH WITH EDGE OF BASE
X
P
L
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Y
E
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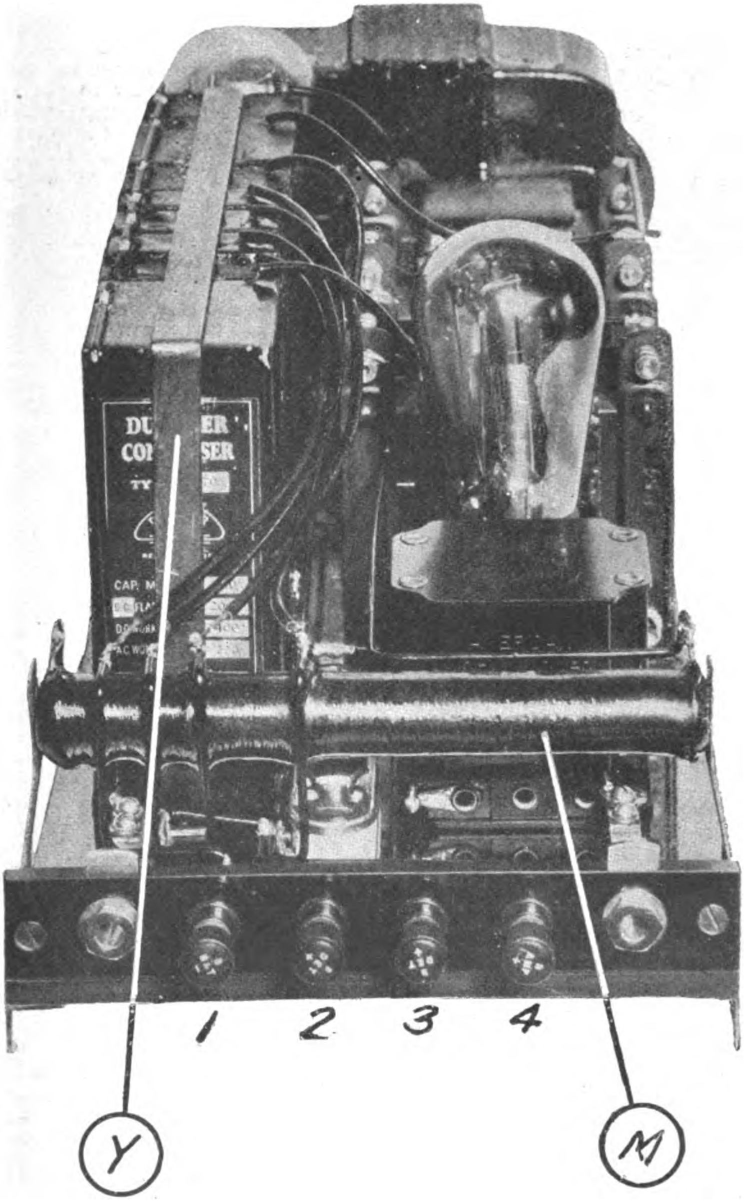
T
A
FACE OF SWITCH TO BE FLUSH WITH EDGE OF BASE
M
N
1
2
3
4
Q
R
O
C
B
D
21"

THE WORKING DRAWING FOR CONSTRUCTION

Figure 4: *This diagram gives the correct dimensions and spacing for mounting all of the component parts of the power-pack amplifier.*



A VIEW OF THE POWER-PACK UNIT FROM THE RIGHT

FIGURE 5: *The unit with the Ward Leonard resistor in place. Notice the input and output jacks and the binding posts which supply the voltages for the set that the unit is used with.*

mally without overload. This means, in short, that the dry-cell set will give as great volume and as fine quality as any other set if the "power-pack" amplifier is plugged in after the first audio-frequency stage of the receiver.

The Theory of Operation

A brief outline of the theory of operation of the power unit may be of interest to the prospective builder. Refer to Figure 1 in tracing through the operation of the unit.

First, note that the power transformer, A, has a secondary winding for lighting the filament of the power tube, R, and another secondary winding for lighting the filament of the rectifier tube, S. Connections to these two filaments are made through center taps of the secondary windings to nullify the effect of the alternating current which is used for filament lighting. For instance, if a connection was made directly to either side of the filament of the power tube, R, a decided hum in the loudspeaker would result.

The third secondary winding of the power transformer furnishes 550 volts of alternating current, which is rectified by the rectifier tube, S, to give a pulsating direct current.

Next, the filter system comprising the choke coils, B and C, and the condensers, E, F and G, smooths out the pulsating current so that at the end of the filter a steady direct current flows through the resistor, M, and also through the choke coil, D, to the plate of the power tube, R.

The extreme lower end of the resistance, M, is negative; and the voltage along it increases to approximately 375 volts at the top. By connecting the grid return of the power tube, R, at the bottom of the resistance and by tapping off the filament of the power tube at the correct distance up on the resistance, as at binding post No. 1, the filament is made positive with respect to the grid or in other words a negative bias is obtained on the grid. Going further up along the resistance, M, to binding posts No. 2 and No. 3, two detector voltages of 18 and 40 volts are obtained. At binding post No. 4 an amplifier voltage of 80 is available; and this may be used to supply the "B" current to all of the remaining tubes of the receiver with which the power amplifier is to be used. The by-pass condensers H, I, J and K are connected across the taps of the resistance, M, to provide lower resistance paths for the audio-frequency currents.

The resistance, N, is shunted across the 80-volt tap of the main resistance, M, to keep the load on this amplifier tap constant. With no amplifier load on tap No. 4 or with a small radio receiver, the resistance, N, can be made low so that it will draw a heavy current. When a large set is connected to tap No. 4 more current will be drawn; but the total load current on this tap may be made the same as before by increasing the value of N and decreasing the current through it.

The direct plate current to the power tube, R, is supplied through the choke coil, D. This direct current is too large and the voltage is too high to apply directly to the loudspeaker, so the audio-frequency current (which produces the sound) is provided with a shunt path from the plate through the condenser, L, and the loudspeaker jack, P, back to the filament of the power tube.

The input to the power unit is made through the jack, O, and the audio-frequency transformer, Q.

Parts Used in Building the Power Unit

In all of the diagrams in this article each part bears a designating letter so that the prospective builder of a set may easily determine how to mount the instruments in the correct places and to connect them properly in the electric circuit.

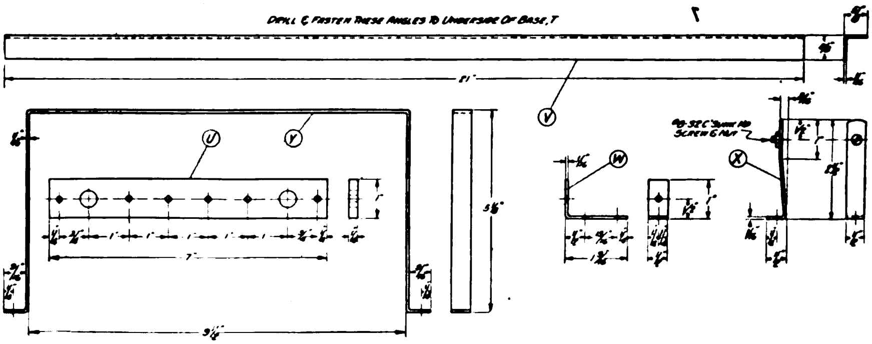
The same designating letters are used in the text and in the list of parts at the beginning of the article.

¶ *The list of parts there given includes the exact instruments used in the set from which these specifications were made up. The experienced amateur, however, will be able to pick out other reliable makes of instruments which may be used with equally good results. But we recommend that the novice follow the list, as the diagrams in this article will tell him exactly where to bore the holes and exactly where to place the connections.*

If instruments other than the ones listed are used, the only change that will be necessary will be the use of different spacings for the holes that are drilled in the sub-base for mounting the instruments.

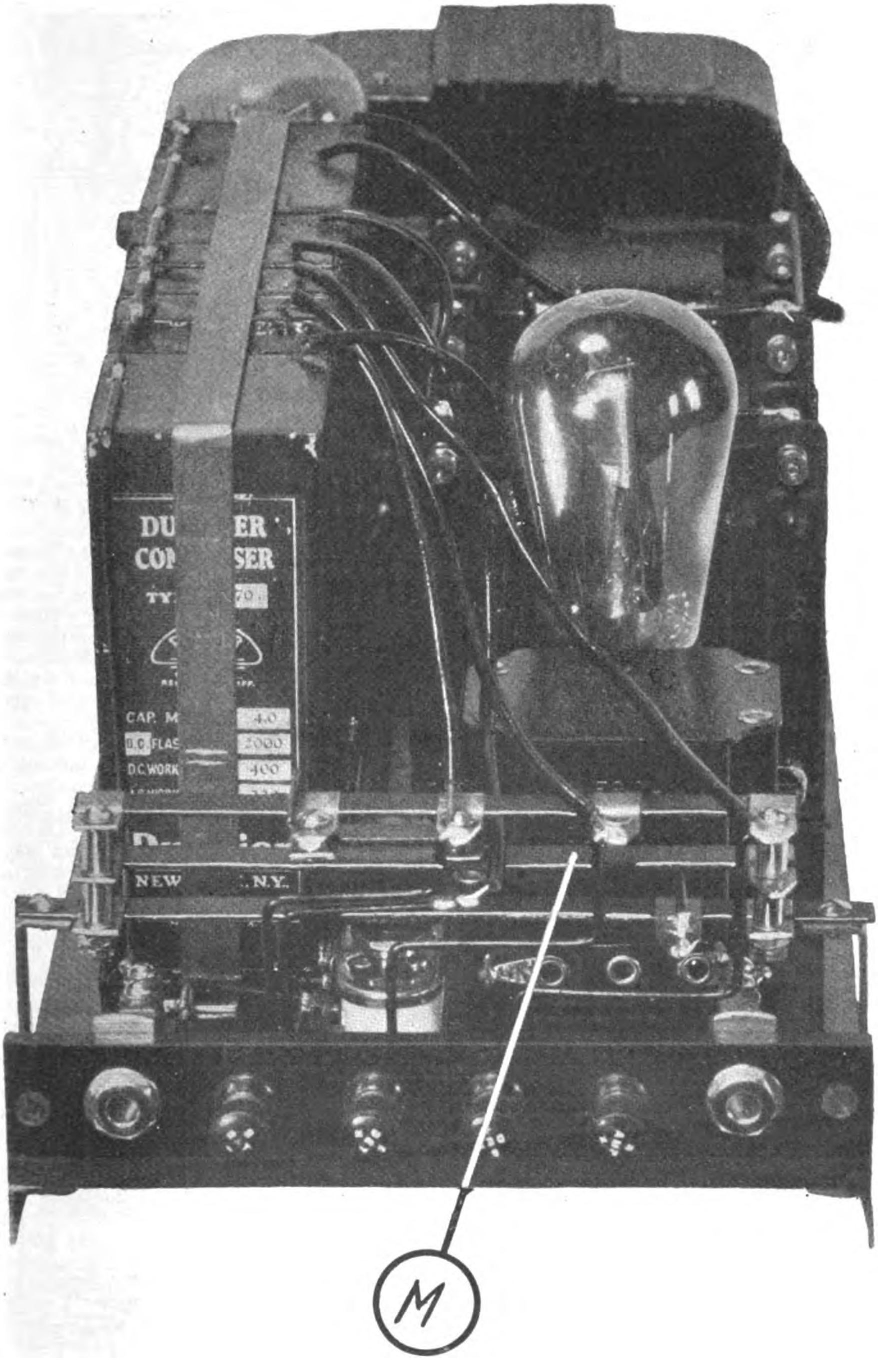
How to Construct the Power Unit

Start the construction work by making the miscellaneous small parts shown in Figure 6.


DRILL & FASTEN THESE ANGLES TO UNDERSIDE OF BASE, T
11"
V
U
Y
W
X
7"
9¼"
1"
6-32 C'SUNK HD SCREW & NUT

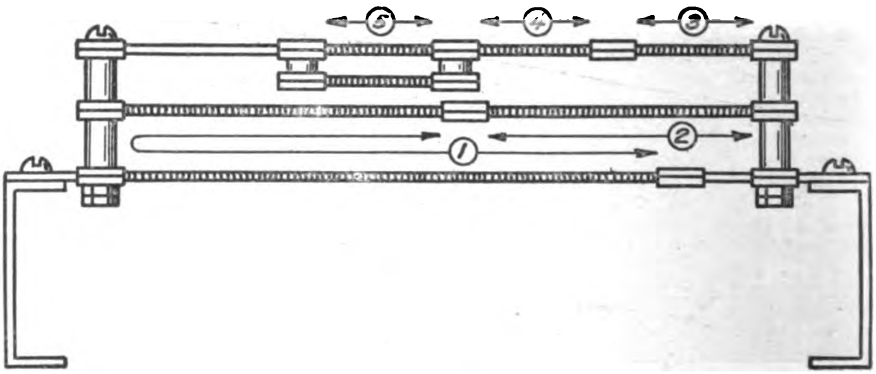
DETAILS OF THE CONNECTION BLOCK, BRASS STRIPS AND BRACKETS

FIGURE 6: *This drawing gives the necessary data for making the insulating strip on which the binding posts are mounted. It also gives the dimensions for the reinforcing angles and the small brass brackets which are used to fasten the condensers, the connection block and the resistance in place.*



ANOTHER RIGHT-END VIEW OF THE UNIT

Figure 7: *This picture shows the instrument with the Aerovox resistor installed. This resistor fits in the same place as the one shown in Figure 5 and the connections are brought out to taps with similar resistance steps. The binding posts, as before, supply the voltages for the receiving set that it is used with.*



THE DIAGRAM OF THE RESISTOR

FIGURE 8: *The construction and taps of the special resistor which is shown in Figure 7 with the resistance stages numbered in accordance with the data given in the list of parts at M may be clearly seen in this drawing.*

First, cut to size the bakelite binding post strip, U, and drill holes for two mounting screws, two jacks and four binding posts.

Next, cut the two angle brass reinforcement strips, V, for the sub-base to length.

Make the two brass angles, W, for holding the binding post strip, out of 1/16-inch by 1/2-inch strip brass.

Using the same strip brass material, make the two brackets, X, for mounting the resistor unit, M. If the Aerovox resistor is to be used it will not be necessary to make these brackets as mounting brackets are attached to the resistor.

Finally bend to size the brass strip, Y, for mounting the filter condensers.

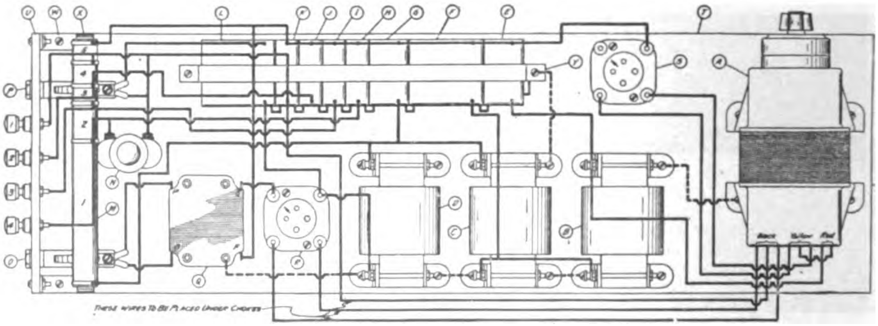
When these small parts are completed begin the mounting of the apparatus by locating the brass angles, W, for the binding post strip, as shown in Figure 4.

The same brass machine screws which hold these brackets may be used to fasten one end of the angle brass reinforcement strips, V, underneath the sub-base.

It should be noted from Figures 2, 3 and 5, that these reinforcement strips are fastened underneath the sub-base with the vertical side flush with the edge of the sub-base. The method of fastening these reinforcement strips was to drill a clearance hole through the sub-base for a flat head 6-32 brass machine screw and to tap the machine screw into the brass strip. One machine screw about an inch from the end of the sub-base and two others spaced centrally should be sufficient.

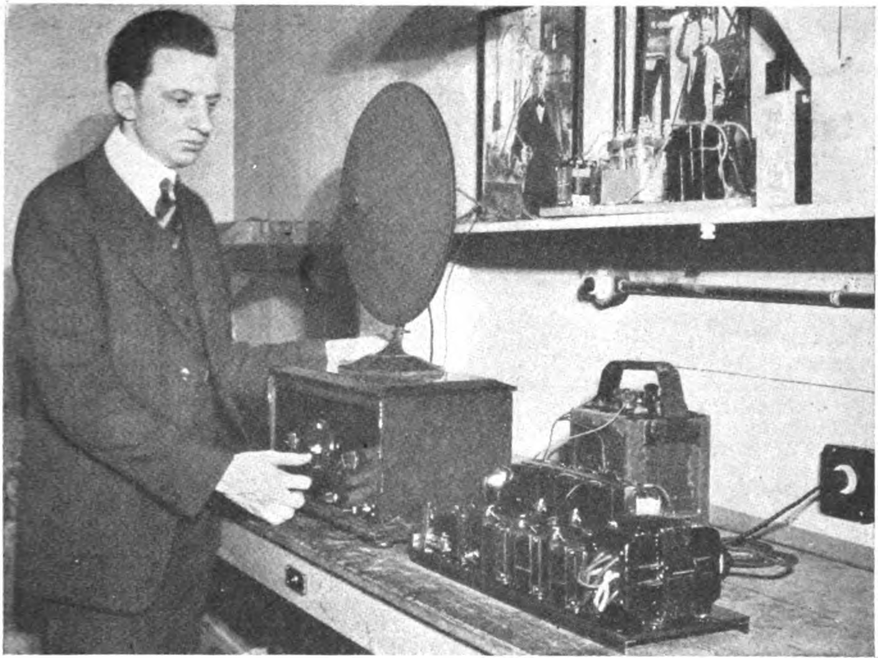
Mount the two jacks, O and P, on the binding post strip, U. Mount the four binding posts from left to right in the following order: B battery minus (−), B detector plus (+), B detector plus (+) and B amplifier plus (+). Then fasten the binding post strip in place on its brackets. (See Figures 4, 5 and 7 for this assembly.)

With two 4-36 brass machine screws fasten the Bradleyohm to the sub-base with the terminals to the rear of the power unit, as in Figure 4. (The front of the power unit is the long side on which the bank of condensers is mounted.)



THE PICTURE WIRING DIAGRAM FOR CONNECTING UP THE INSTRUMENTS

FIGURE 9: *All of the instruments have been drawn in their approximate positions. The heavy black lines show the exact way to run the wires for connecting up the instruments. (Full-scale blueprints for assembling and wiring this device may be obtained by sending in $1.00 to* POPULAR RADIO SERVICE BUREAU.)



THE AUTHOR TESTS OUT THE UNIT

In this picture, Mr. Craig is shown with the unit installed in conjunction with the new S-C receiver. For installation in the home, the unit itself should be placed inside of the radio cabinet in the place generally occupied by the "B" batteries.

Next fasten the two sockets, R and S, to the sub-base with round-head brass machine screws, placing the plate and grid terminals toward the rear of the unit. (See Figures 2, 3 and 4 for the exact locations.)

Fix the audio-frequency transformer, Q, in position, as shown in Figures 2 and 4, with the plate and "B" plus (+) terminals toward the binding post strip.

Now mount the three choke coils, B, C and D, with their terminals toward the binding post strip, as shown in Figures 2 and 4.

Use round-head 8-32 brass machine screws for the heavy power transformer A and locate it according to Figures 2, 3 and 4 with the switch at the rear of the power unit.

Place the condensers E, F, G, H, I, J, K and L in order, beginning near socket S, and secure them to the sub-base with the brass mounting strip, Y.

Using brackets X, mount the Ward Leonard resistance unit, M, with the long untapped portion near the front of the set. (See Figures 4 and 5.)

If the Aerovox resistor, M, is used fasten it in place with the soldering lugs toward the binding post strip, as shown in Figure 7.

This completes the mounting of apparatus for the power unit.

How to Wire the Power Unit

In connecting up the unit, refer to the wiring diagram which is given in Figure 9.

Connect the top terminal of the input jack, O, to the plate terminal of audio-frequency transformer, Q, and the bottom or frame terminal of jack, O, to the B plus (+) terminal of the transformer. Then join the grid terminal of the transformer, Q, to the grid binding post of the socket, R.

Connect the plate binding post of the socket, R, to the near side of the condenser, L, and to the front binding posts of the choke coil, D.

Connect the two outside yellow filament leads of the transformer, A, to the filament binding posts of the socket, S. Join the central yellow filament lead at the transformer to the red high voltage lead below and to the right of it. Run the three black filament leads of the power transformer, A, along underneath the choke coils, B, C and D; and connect the two outside black leads to the filament binding posts of the socket, R.

Connect the plate terminal of the socket, S, to the rear side of the condensers, E, F, G, H, I, J and K; and continue the same wire to the filament terminal of the audio-frequency transformer, Q, and to the outside terminal of step 5 of the resistor, M.

Connect the central black filament lead of the power transformer, A, between step 4 and step 5 of the resistor, M, to one side of the Bradleyohm, N, to the B battery minus (—) binding post, No. 1, to the front terminal of condenser, K, and to the bottom or frame terminal of the output jack, P.

Join the top terminal of the output jack, P, to the rear terminal of the filter condenser, L.

Connect the "B" detector plus (+) binding post, No. 2, between steps 3 and 4 of the resistor, M, and also to the front terminal of the condenser, J. Connect the "B" detector plus (+) binding post No. 3, between steps 2 and 3 of the resistor, M, and also to the front terminal of the condenser, I. Connect the "B" amplifier plus (+) binding post No. 4, between steps 1 and 2 of the resistor, M, to the front terminal of the condenser H, and also to the remaining terminal of the Bradleyohm, N.

Connect the red left-hand high voltage lead of the power transformer, A, and also the front lead of the condenser, E, to the rear binding post of the choke coil B. Join the two front leads of the choke coils, B and C, and connect them to the front terminal of the condenser, F. Join the two rear terminals of the choke coils, C and D, and the front terminal of the condenser, G; and continue this wire to the outside end of step 1 of the resistor, M. For the distribution of the resistance steps of the Aerovox resistor, see Figure 8.

Complete the wiring by grounding the cores of the transformer, A, the choke coils, B, C and D, the audio-frequency transformer, Q, and the metal cases of the condensers, E, F, G, H, I, J, K and L, to the "B" battery minus (−) binding post, No. 1. The ground wires may be conveniently run from one mounting screw to another beneath the sub-base.

How to Install the Power Unit

First find out the voltage of the AC lighting supply with which the unit is to be connected. This may be done by noting the voltage marked on two or three electric light bulbs. Set the switch of the power transformer, A, on tap No. 1 for 120 volts, tap No. 2 for 115 volts or tap No. 3 for 110 volts. This switch should be set once for the correct voltage; and it should not be used for turning the power unit on and off.

Insert a UX-216-b rectifier tube in socket S, and a UX-210 tube in socket R. Then screw the Bradleyohm, N, down tight.

To test the power unit insert the attachment plug in an electric light socket. Both tubes should now light to approximately the same briliancy as those in an ordinary receiving set; and the resistor, M, should heat up noticeably in a few minutes. If all steps on the resistor show some heating effect (even though the amount of heat may vary) the power unit is probably working all right and supplying high voltage direct current.

Disconnect the power unit from the electric light socket. Plug the loud speaker in output jack P and, using a cord with a plug on each end, connect the input jack, O, to the first stage jack of the receiver with which the unit is to be used.

Now reconnect the power unit to the electric light circuit and it should give power amplification of excellent quality. Try reversing the input leads to the jack, O, for the best results.

With these connections the power unit is being used as a stage of power amplification only. To use it also as a "B" battery eliminator first disconnect the unit from the electric light socket, then remove the "B" battery (−) lead of the receiver from the "B" batteries and connect it to the "B" battery (−) binding post, No. 1, of the power unit. Remove the "B" detector (+) lead of the receiver from the "B" batteries and connect it to the "B" detector (+) binding post, No. 2, of the power unit if you are using a soft detector tube or to the "B" detector plus (+) binding post, No. 3, if you are using a hard detector tube. Remove the "B" amplifier plus (+) leads of the receiver (either AF or RF or both) and connect them to the "B" amplifier plus (+) binding post, No. 4, of the power unit. The grid-bias which is used on the amplifier tubes should be 3 to 4½ volts.

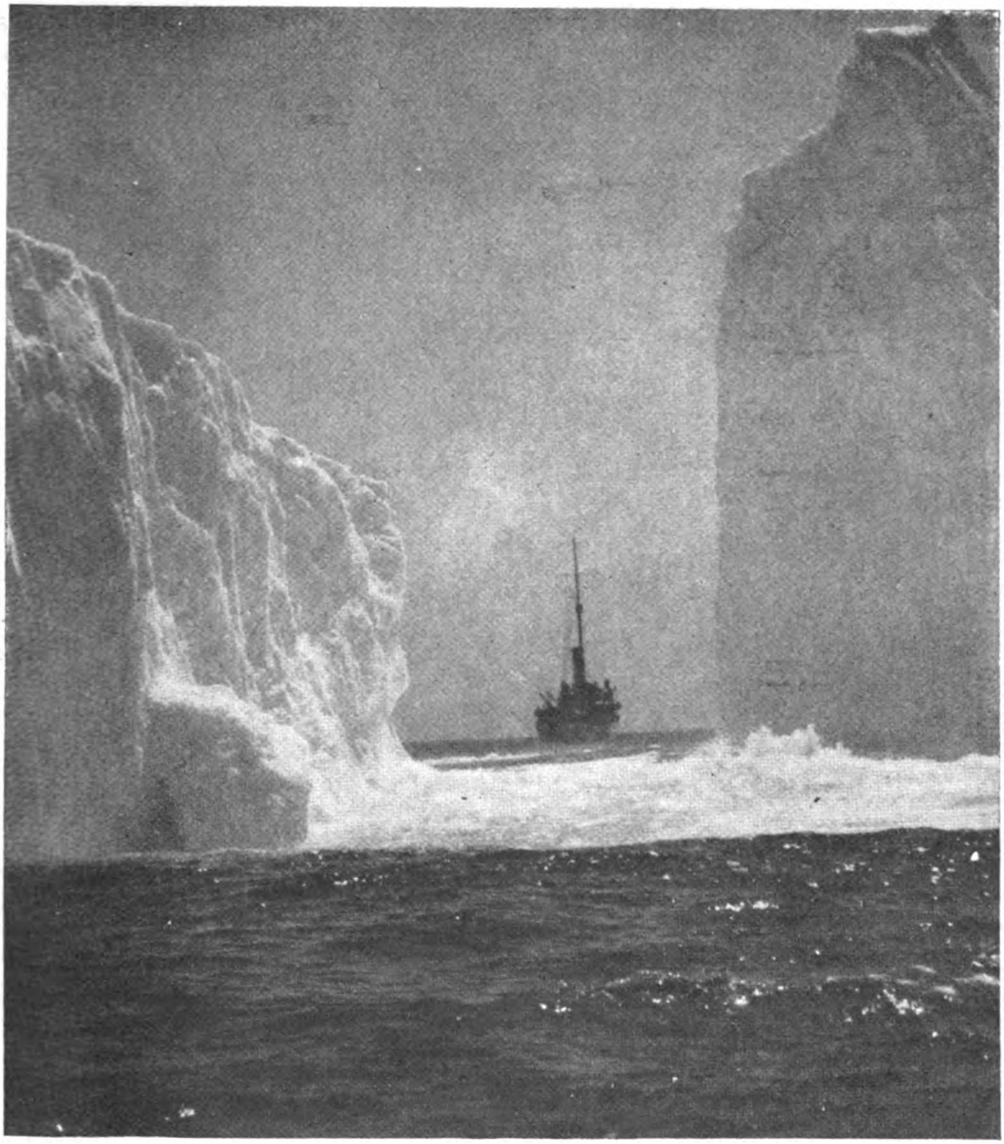
Plug the power unit back in the electric light socket and it will function both as a stage of power amplification and as a "B" battery eliminator.

The Bradleyohm, N, should be adjusted until the detector voltage is correct. In general it will have to be unscrewed further for multi-tube sets.

Always turn off the power unit when making adjustments.

How to Build the New Power-pack

IN POPULAR RADIO *for May—next month—will appear an article that gives complete constructional details on the new Raytheon "Power-pack" that furnishes plate current for any type of radio set now in use for broadcast reception. This Power-pack will supply a plate voltage up to 170 volts for the last stage, and for resistance-coupled amplifiers; it will supply voltages varying between 60 volts and 125 volts for radio-frequency work or for low-power audio amplifiers; and it will supply voltages ranging between 10 and 50 volts for use on the plate circuits of detectors. This new development is a great improvement over the old style of Raytheon Plate-supply Unit, in which only one variable voltage can be obtained. Order your May issue from your newsdealer today.*



A Radio Patrol of the Seas

Over 1,500,000 words were transmitted by radio last year from Uncle Sam's Coast Guard vessels that have been designated as the "International Ice Patrol," to warn shipping of the shifting locations of icebergs. These lonely scouts of the sea are equipped with the latest and most approved type of radio apparatus, as the usefulness of this unique service to mankind rests entirely upon communication that only radio can make possible.

Westinghouse

A HUGE RADIO TUBE AND THE TINY CRYSTAL WHICH HOLDS THE STATION ON ITS WAVEBAND

Here is one of the large water-cooled transmitting tubes; the small object to the right is a small quartz crystal which is used in a crystal oscillator to control the frequency of the generator current that keeps the station transmitting on its exact wavelength.

The New "Crystal Pilot"

for holding broadcasters to their wavelengths

That peculiar whistle which bothers every radio fan when he tunes in on distant stations that operate on nearly the same wavelengths is caused by the distortion of radio waves that collide with each other—because one of the stations "slides off" the waveband assigned to it. This fault is now being checked with the aid of a tiny crystal oscillator—which thus becomes an object of vast importance to all broadcast listeners.

By THOMAS L. BAYARD.

"THERE'S a good program on XYZ tonight," observes the visitor. "Can you pick up that station well from here?"

"Sure!" replies the confident host. "I often tune in on XYZ." And he turns the dials of his receiving set. "I usually get it right here," he explains.

Whereupon the loudspeaker emits a too-familiar whistle.

The fan makes a further adjustment of a dial. Music can be faintly heard—

but the whistle still remains. He turns another knob—"turning back the tickler," he calls it—but the whistle continues at the same pitch at which it was first heard. The music is a queer medley of sounds; it appears to be a mixture of two selections from different stations.

"They come in that way sometimes," the radio fan mutters apologetically as he works at the dials. "I can't understand it."

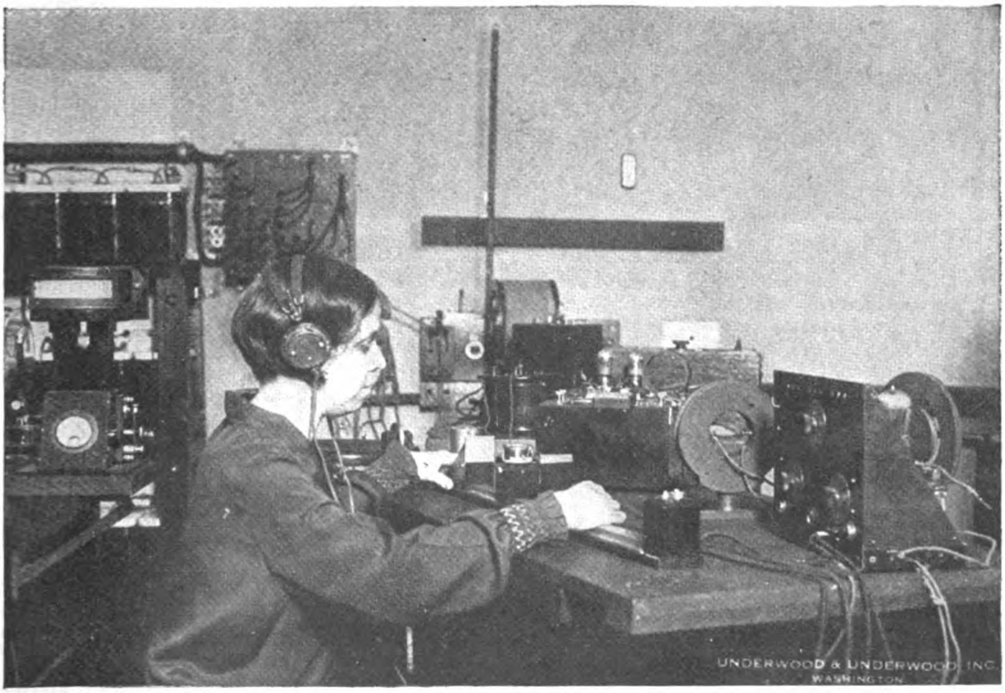
And in spite of all the fan can do, the whistle stays at the same unbroken pitch.

The Whistle and Its Cause

The fan "can't understand it" because he believes his receiving set is at fault. But the whistle in this case is caused not by the receiving set; it is caused by interference between the two stations. This interference in turn is caused by one of the stations—or possibly by both—because they are off their assigned wavelengths.

The American broadcasting stations now are assigned wavelengths or frequencies that are separated from each other by exactly 10 kilocycles. That is, there is a difference of 10,000 cycles a second between the frequencies of the different stations. These two stations, which are being received at the same time by the fan, instead of being separated by the 10 kilocycles which is presumed to intervene between them, actually may be separated at the moment by only half or a third of that number.

The oil condenser used by one of the stations, for instance, may have become hot. This condition often results in a wide shift in the frequency of the wave that is transmitted. If the oil used for filling the condensers of this type—a type



Underwood & Underwood

HOW QUARTZ CRYSTALS ARE STANDARDIZED

The exact frequency at which quartz crystals of different sizes will oscillate is here being determined in the Bureau of Standards by means of a sonometer. When the exact point of oscillation has been determined these crystals may serve as frequency standards for broadcasting stations.

Westinghouse

A CRYSTAL OSCILLATOR IN OPERATION

The operating panel of the crystal control circuit that keeps the whole transmitter of a broadcasting station functioning at the proper frequency is shown above. The quartz crystal is mounted on the panel just to the left of the hands of the chief operator of the station, who is adjusting the control.

that is used on many of the American transmitting sets—is not of exactly the right quality, it is apt to become hot under operation and cause the frequency of the transmitted wave to rise as much as three or four kilocycles. If the wavemeter used by the station is not accurate —many of them are not—and the operating staff is not especially alert, it is possible for as great a shift as three or four kilocycles to occur without being noticed by the staff. Other factors may cause the shift, a detail as seemingly trivial as a fluctuation in the plate voltage supplied to the transmitting set, or the swaying of the antenna in the wind.

Whatever the cause, the frequency of station XYZ has shifted and is heterodyning the wave of the station which is next to it in the broadcasting band. This heterodyning is causing, in the receiving set of the listener-in, a whistle. The pitch of the whistle is constant and is established by the difference in frequency between the two stations.

How the Whistle Is Produced

The radio amateur understands what this heterodyning is because it involves a principle used in one of the most widely known and most selective radio receiving sets.

For those who do not know what heterodyning is an analogy may be drawn of a man and a boy walking together across a bridge. If the man takes six steps to cross the bridge while the boy requires nine, they will be out of step part of the time and in step part of the time. If another person is under the bridge listening to their footsteps, he will hear a patter of light footfalls when the two pedestrians are out of step. But he will hear, when the pedestrians tread on the bridge at the same instant, a single footfall approximately twice as loud as the others.

This loud footfall will occur three times while the men are crossing the bridge, which, it should be noted, is the difference between the man's six steps and the boy's nine. If the man and boy are running instead of walking these three loud footfalls will be heard by the person under the bridge as a sharp "rat-tat-tat" that is independently of the rest of the footfalls.

This serves to illustrate how the beat note is caused when two transmitted radio waves are picked up in a receiver at the same time. When the waves are in step or "in phase," their strength is combined and when they are "out of phase" they tend to neutralize each other.

So when radio waves are in step and their strength is combined, the resulting signal is considerably stronger than when they are out of step and therefore neutralizing each other.

This quick rise and fall in the strength of the radio signals as the two waves alternately are in phase and out of phase may be several hundred times a second—so rapid that it sets up in the receiving set an audible tone or whistle that has its own pitch.

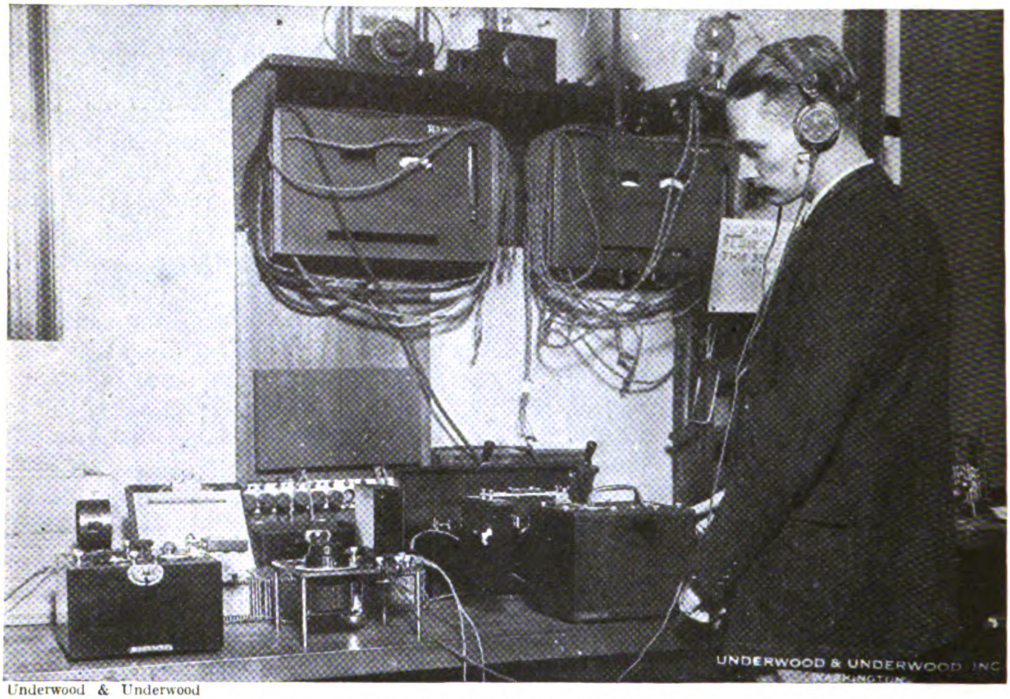
The frequency or pitch of this tone is the difference between the frequencies of the two original waves. The pitch of this tone, it also should be noted, is constant, and it cannot be made to vary by any manipulation of the receiver, as can another kind of whistle which will be noted later.

It commonly happens that when the listener-in hears this interfering beat note or heterodyne whistle, he may also hear the music or speech from two different stations jumbled together, with the sounds from one station perhaps louder than those from the other. Or if the two stations cannot be heard at the same dial setting, the listener-in may find that while he hears only one station, he is troubled by the interfering beat note caused by the wavelength of a neighboring station which is too close to the one he hears.

The listener-in who is getting this interference whistle in his set can tell, if he cares to do so, whether the two interfering stations are as close together as four kilocycles. He can do this by comparing the pitch of the whistle with the notes of a piano. If the stations are four kilocycles apart (4,000 cycles a second) it is about the frequency of the last key to the right C, in an 88-key piano. If the stations are three kilocycles apart, the beat note frequency, 3,000 cycles, will be about that of the highest G of the piano. If the stations are as close as two kilocycles the pitch of the whistle will be about that of the C which is next below the highest C and which vibrates 2069 times a second. If they are separated by only one kilocycle the pitch of the whistle will be approximately that of the next C below the one just mentioned.

The Hunt for a Remedy by Means of Crystals

Radio engineers and the United States Bureau of Standards have been working to eliminate this interference. The Bureau of Standards has been helping the stations keep to their assigned wavelength by checking their wavelengths periodically, as it has been a difficult matter for the stations to measure accurately a wavelength that is radiated at perhaps as high a frequency as a million cycles a second. To assist the stations to gauge this



Underwood & Underwood

ANOTHER USE OF THE PIEZO-CRYSTAL AS A FREQUENCY STANDARD

A set-up for a piezo-crystal oscillator and an auxiliary generator design for the standardization of wavemeters which is in use at the Bureau of Standards in Washington. Great accuracy may be obtained by the use of the crystal itself in a wavemeter.

frequency, the Bureau also has devised a wavemeter to be used by the station. Constant vigilance on the part of the staff of a station that uses one of these wavemeters may reduce this frequency fluctuation very materially, yet the station that stays within two or three kilocycles of its assigned frequency is doing very well.

The engineers of the Westinghouse Electric & Manufacturing Company, in their search for ways of maintaining a constant frequency in the company's broadcasting stations, investigated the possibilities of an automatic control of this frequency. They had known that certain crystals, called piezo-crystals, had the property of vibrating when electrically excited. So they investigated the possibility of using these crystals to control the frequency of a transmitting set.

It was known that the vibrations of any given piece of piezo-crystal were remarkably constant and that the size and shape of the crystal governed the frequency of these vibrations. Several month's experimental work on the KDKA short-wave transmitting set established the fact that the vibrations of the crystal could be amplified and radiated by the powerful short-wave transmitting set, at its normal energy output, without a change in frequency.

The short wave set has been constantly operated under crystal control since July and shows none of the shifts in wavelength to which the American broadcasting stations as a rule are subject. Not only will the ordinary causes fail to produce a change in the frequency of this set, but even deliberate efforts on the part of the operating staff will not cause it to change. The amount of energy radiated will drop if the transmitting circuit is thrown out of tune, but the frequency will remain constant.

So satisfactory has the crystal control

proven under the exacting conditions on the KDKA short wave set that the company is equipping all of its broadcasting stations, (KDKA, KYW, WBZ, and KFKX), with the crystal control. One of the specially designed transmitting circuits has been built for the KDKA assigned wavelength set, and it is now being used during all of the regular broadcasting periods. A few other stations have also adopted the crystal control.

How to Tell If a Station Employs the "Crystal Control"

The listener-in who has a regenerative receiver of the coupled circuit type will be able, by means of a simple test, to tell whether any given station has adopted crystal control of its transmitting set.

In this test a whistle is produced—a whistle that sounds something like the one caused by interference between two stations but which must not be confused with it. This new whistle is the one that is caused by an oscillating receiving set that is heterodyning a broadcasting station, and its pitch may be changed by turning the tuning dial. To produce it, the amplification dial or "tickler" must be turned on until the set begins to oscillate, and the set tuned very closely to the station which is being tested. When this is done, the whistle will be produced.

If the listener-in is not certain whether he has the right whistle, let him turn his tuning dial slightly; if the pitch of the whistle changes as the dial is turned, he has the right one.

Now let the listener-in take his hands away from his set and listen to this whistle.

If the whistle is a steady, even, unvarying tone, it is safe to assume that the station is using crystal control. If, however, there is a change or drift in the tone, it is safe to assume that no crystal is being used.

This change or drift in tone, if one occurs, will be easy to recognize. The change may be so rapid and regular that the whistle will sound like the siren on a fire engine that is answering an alarm, or it may be slow, like a singer warbling irregularly up and down the musical scale, a tone at a time.

The change in this tone is caused by a change in frequency of the broadcasting station, which is impossible when the station which is transmitting is controlled by means of a piezo-crystal.

Changes in the List of Broadcasting Stations in the U. S.

These corrections and additions to the list which was published in the March, 1926, issue of POPULAR RADIO *make it correct as of February 20, 1926. Further changes will be published each month in this magazine.*

STATIONS ADDED

KFYO	Texarkana, Tex.	209.7
KWUC	Le Mars, Ia.	252
WABB	Harrisburg, Pa.	204
WATT	Boston, Mass.	243.8
WCOA	Pensacola, Fla.	222.1
WHBY	West de Pere, Wis.	250
WJBR	Omro, Wis.	227.1
WQAC	Amarillo, Tex.	234.2
WSAU	Chesham, N. H.	229

CHANGES IN CALL LETTERS

KFCF	Walla Walla, Wash., *should be changed to*	**KOWW**
KFDJ	Corvallis, Ore., *should be changed to*	**KOAC**
KFMQ	Fayetteville, Ark., *should be changed to*	**KUOA**
KFXC	Santa Maria, Cal., *should be changed to*	**KSMR**
WDBR	Boston, Mass., *should be changed to*	**WSSH**
WEBK	Grand Rapids, Mich., *should be changed to*	**WOOD**
WEPI	Newark, N. J., *should be changed to*	**WBPI**
WJBP	Buffalo, N. Y., *should be changed to*	**WSVS**
WJBQ	Lewisburg, Pa., *should be changed to*	**WJBU**

STATIONS DELETED

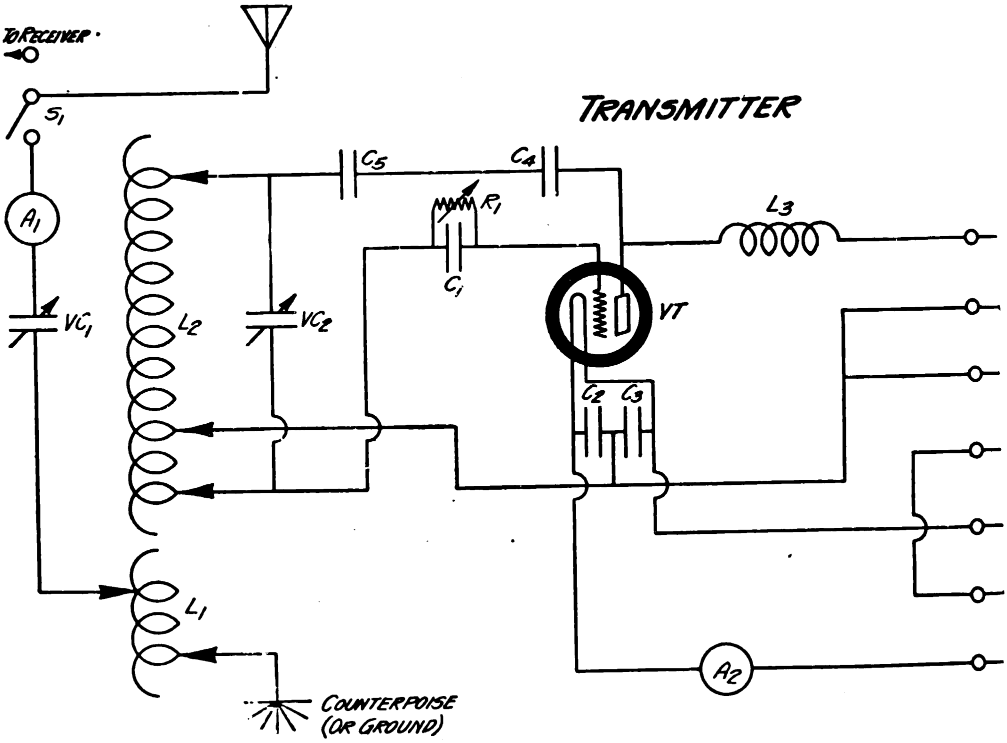
KFGH	Stanford University, Cal.	270
KFOJ	Moberly, Mo.	242
WDCH	Hanover, N. H.	256
WGBK	Johnstown, Pa.	248
WIBC	St. Petersburg, Fla.	222
WJBN	Sycamore, Ill.	256
WRAK	Escanaba, Mich.	256
WTAC	Johnstown, Pa.	268

CHANGES IN WAVELENGTHS

KFAU	Boise, Ida., 282.8, *should be changed to*	**280.2**
KFBC	San Diego, Cal., 224, *should be changed to*	**215.7**
KGTT	San Francisco, Cal. 234, *should be changed to*	**206.8**
KOAC	Corvallis, Ore., 282.8, *should be changed to*	**280.2**

CHANGES IN LOCATIONS

KMOX	St. Louis. Mo., *should be changed to*	**Kirkwood, Mo.**
WHBL	Logansport, Ill., *should be changed to*	**Chicago, Ill.**
WIOD	West Palm Beach, Fla., *should be changed to*	**Miami Beach, Fla.**



HOW TO BUILD AND OPERATE

A Low-power Transmitter

For the radio experimenter who has reached the stage when he feels the urge to step from the listener class into the exclusive transmitter class, this low-power transmitter is recommended—not only because it is easy to build and because the parts may be obtained for only about $25.00, but also because the set has a daylight range of about 500 miles.

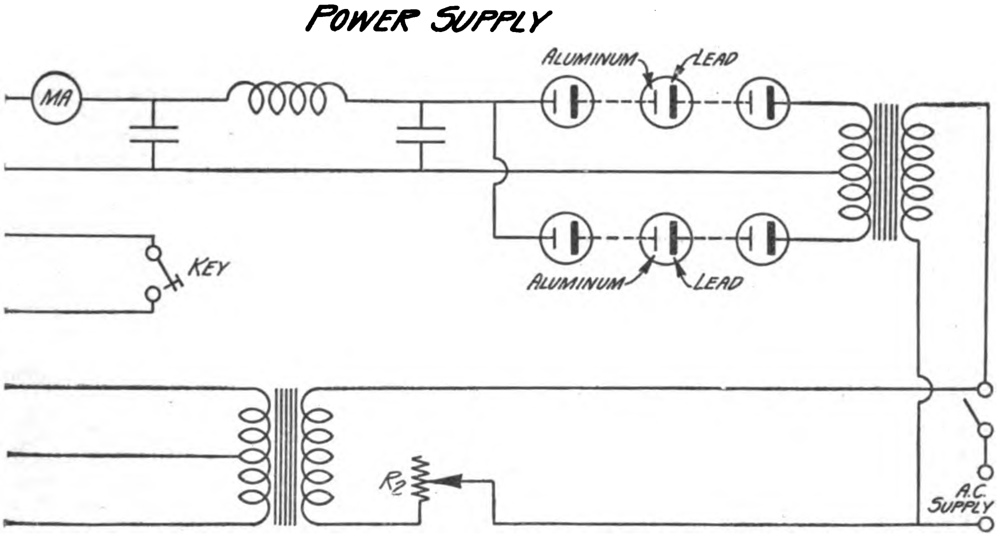
By GORDON FRASER.

List of Parts Used in the Laboratory Set

*A1—General Radio Model 127C hot wire ammeter, range 0 to 1 ampere;
*A2—General Radio Model 127A hot wire ammeter, range 0 to 1.5 amperes;
C1—Sangamo fixed condenser, .0015 mfd. capacity;
C2 and C3—Sangamo fixed condensers, .003 mfd. capacity;
C4 and C5—Sangamo fixed condensers, .002 mfd. capacity;
L1—20 turn coil (see text for constructional details);
L2—15 turn coil (see text for constructional details);
L3—Choke coil (see text for constructional details);
*MA—Weston Model 301 DC milliammeter, range 0 to 100 milliamperes;
R1—Bradleyohm No. 25 variable resistance, range 25,000 to 250,000 ohms;
S1—Barkelew antenna switch, single pole, double throw;
VC1—Cardwell variable receiving condenser, with a capacity between .00025 and .0005 mfd.

THE SCHEMATIC DIAGRAM OF THE TRANSMITTER

FIGURE 1: *This drawing shows the complete hook-up of the low-power transmitter, together with the power supply equipment which was described in the January issue of* POPULAR RADIO. *The circuit employed here is the coupled Hartley with shunt feed.*



VC2—Cardwell variable receiving condenser, .00025 mfd. capacity;

VT—Pacent Universal Isolantite socket.

*These meters may be all the same make. In the model of this transmitter the author used the meters that happened to be at hand at the time. The important considerations in selecting the meters to use are that they have the proper range, as given above, and that they be of the type mentioned, i.e., hot wire meters in the case of A1 and A2, and DC meter in the case of MA.

¶ *The list of parts here given includes the exact instruments used in the unit from which these specifications were made up. The experienced amateur, however, will be able to pick out other reliable makes of instruments which may be used with equally good results. But we recommend that the novice follow the list, as the exact arrangement of instruments as shown in the illustrations may then be used. If any substitutions are made it is well to remember that high voltages are being dealt with and that the substitute instruments which are used must be selected accordingly.*

WITH the popularization of short-wave reception many radio fans, whose knowledge of the subject has previously been confined to broadcast reception, are beginning to evince a decided interest in amateur short-wave transmission. This is natural enough since it is a short step from experimental reception to the field of transmission.

There is no better way to obtain a thorough practical knowledge of radio than by "going on the air" with a low power transmitter. High power broadcasting has to some extent eliminated the necessity for high efficiency in broadcast receivers and caused, perhaps, a certain amount of carelessness in construction; but in the case of a transmitter using low power the utmost efficiency is absolutely necessary. And it is this necessity that forces upon the experimenter a better understanding of the fundamental principles of radio and what constitutes real efficiency.

The transmitter that is here described is truly a low power transmitter inasmuch as the total power input to the transmitter is considerably lower than that which is put into a single electric light bulb. Using a UX-210 power tube, which has a rated output of 7½ watts, the power input is between 20 and 25 watts.

To the non-transmitting amateur it may seem almost unbelievable that a transmitter using such low power can actually provide a reliable means of communication with other amateurs half way across the country. As a matter of fact, such transmitters have been heard thousands of miles away, and it is not uncommon for an American amateur, using power as low as this to be heard in European countries, although these feats are usually the result of exceptionally favorable conditions.

The small transmitter described here has a reliable night-time range of somewhat in excess of a thousand miles. Greater distances have been covered, but not consistently.

This transmitter was designed for use on the short-wave amateur bands around 40 and 80 meters, because these are considered to be the most practical working bands for amateurs. Daylight transmission on 40 meters compares favorably with night transmission on the higher wavelengths. It has a consistent daylight range of over 500 miles on a 40 meter wavelength. Two-way communication between this transmitter in New York City and amateurs in Chicago has proven to be quite consistent during the forenoon.

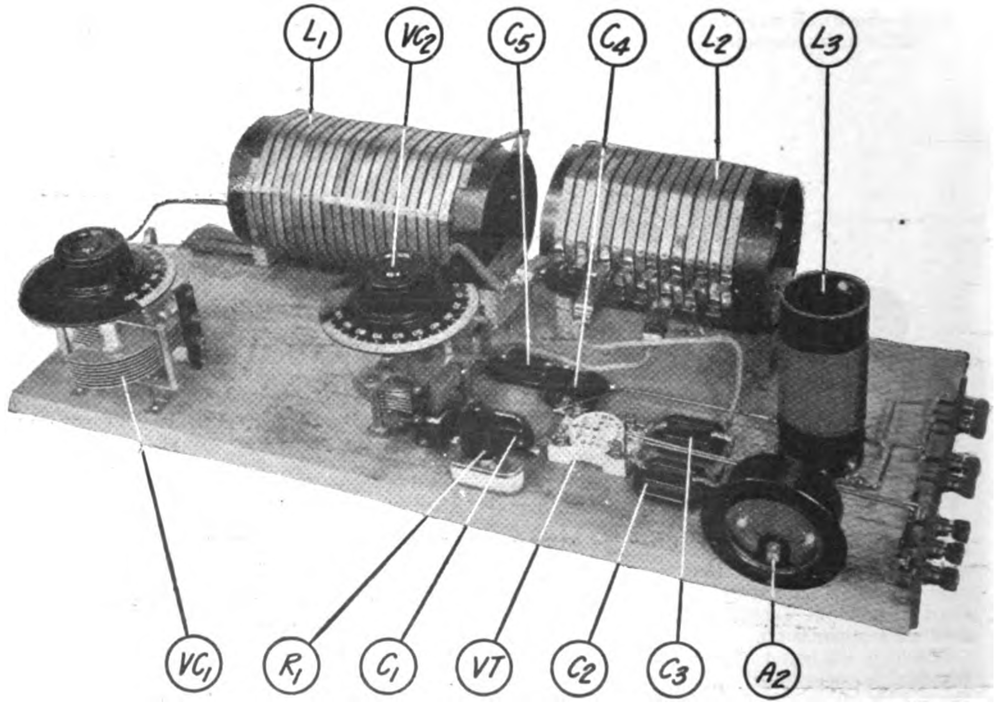
It will be noted from Figure 1 that the circuit and construction of this transmitter are much like that of an ordinary regenerative short-wave receiver. More than this, a number of the instruments used, such as the variable and fixed condensers, are the same as those which are used in receivers.

The coils, in which lies the main difference between this transmitter and a receiver, are homemade. The constructional details are shown in Figure 4. The foundation for the two necessary coils consists of radion tubing 4 inches in diameter and ⅛ of an inch thick. On this tubing 8 strips of radion of the same length and 3/16 of an inch square are laid lengthwise, equidistant around the circumference of the tube.

It is well to fasten these strips to the tube to hold them in place during the winding process. This may be done by drilling small holes through the ends of the strips and tubing and twisting pieces of wire through these holes. The coils, which consist of 25 gauge copper ribbon ¼ of an inch wide by 1/64 of an inch in thickness, are wound on top of these square strips.

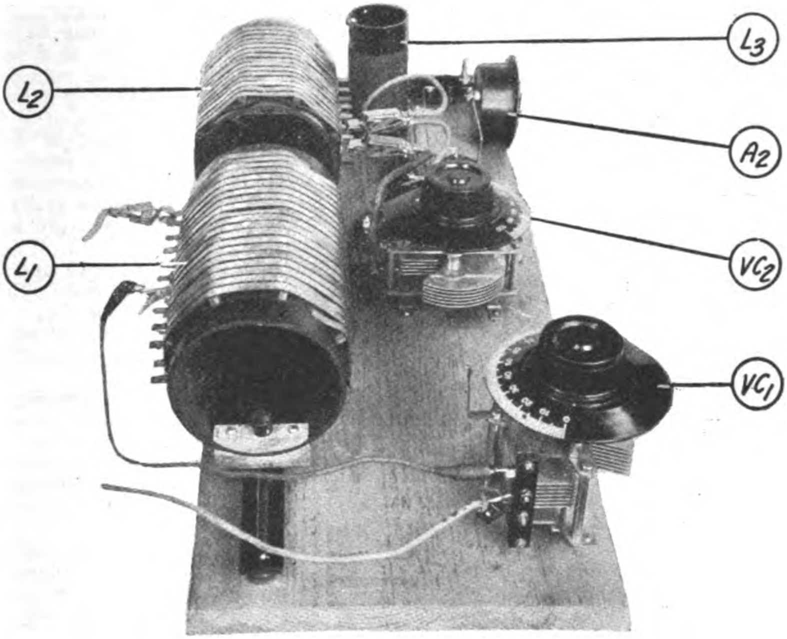
Thus each turn is supported at 8 points but between points is in contact only with the air. To prevent turns from slipping indentations may be made, as illustrated, through the copper ribbon and into the rubber strips with a center punch. After completion of the windings the superfluous ends of the rubber strips may be cut off.

The closed circuit coil L2, which is shown in Figure 4, consists of 15 turns spaced 1/16 of an inch apart. L1 has 20 turns. Used in conjunction with the variable condenser VC2, coil L2 will easily cover the 80 meter amateur band, and of course may be tuned down by means of the clips and the condenser to the 40 meter band.



A FRONT VIEW OF THE TRANSMITTER

Figure 2: *This illustration gives a good idea of the layout and spacing of the instruments. The designating symbols shown correspond exactly with those in the other figures and in the list of parts given above. The coil L2 is fastened to the baseboard by means of screws run through from the bottom of the baseboard into the coil mounting blocks.*



AN END VIEW THAT
SHOWS THE COIL MOUNTING

FIGURE 3: *The method used to mount the outer end of coil L1 is illustrated here. By means of the slide on which it is placed coil L1 may be moved towards or away from L2 to provide the necessary degree of coupling. Complete details are shown in Figure 5.*

It is the antenna inductance that presents the main problem inasmuch as its size will depend a good deal upon the antenna with which it is used. However, 20 turns should be ample.

After the coils are wound, a lug is soldered on each turn so that contacts may be made by means of flexible leads and clips. See Figure 4 for details. The mounting blocks are then also attached.

The only other item of the equipment to be constructed by the builder is the choke coil, L3, which consists of 146 turns of No. 28 wire wound in a single layer on composition tubing 2 inches in outside diameter. It is important that this coil should not be larger than specified because the choke coil should have a natural period somewhat lower than 40 meters if the transmitter is to be worked on that wavelength. Otherwise its effectiveness will be decreased.

The blocking condensers C4 and C5 really serve as a single condenser. The voltage to which they are subjected is somewhat in excess of the rating of the small type of receiving condenser, and for that reason two of these condensers were used in series in constructing this transmitter. If desired, a single transmitting condenser of .0015 may be used in place of the two specified. For the grid condenser, C1, and the filament by-pass condensers, C2 and C3, the ordinary receiving condensers are entirely satisfactory.

Space does not permit a detailed description of the layout of the baseboard and instruments. However, the illustrations give sufficient information to permit the builder to follow this without trouble.

The hot wire ammeter, A2, is used to indicate the current flow in the filament circuit of the tube. A meter with a range of 1.5 amperes is suitable because the UX-210 or VT2 type of tube filament current requirements are within this range. In addition to this meter two others are used as indicated at A1 and MA in Figure 1. The former is used to measure the current flow in the antenna circuit so that it indicates when the antenna circuit is tuned to resonance with the closed circuit.

The reading of this meter, however, gives no final indication of the operating efficiency of a transmitter. In general, the best antenna current reading that can be obtained *at a given wavelength* indicates the greatest efficiency. And differing antenna current readings at different wavelengths do not necessarily indicate that the operating efficiency of the transmitter has risen or fallen. The fact is that a change in the characteristics of the antenna circuit is reflected in a change in the antenna ammeter reading just as readily as a change in the efficiency of the transmitter.

The meter MA measures the current flow in the plate circuit of the tube. This meter is not essential but its use is advised since it helps to indicate the efficiency of the transmitter on a given wavelength. This efficiency increases as the plate current, needed to maintain the antenna current reading at the highest obtainable, decreases.

The meters A1 and MA may be permanently mounted in the transmitter if desired. However, most amateurs do not have many spare meters and it is a good plan to arrange things so that the meters can be quickly removed for other temporary use if desired. Thus these two meters are not mounted in the model described here.

The Antenna

The transmitting antenna should, of course, be as efficient as possible. It should be kept clear of trees and buildings in so far as this is possible. If iron pipe masts are used to support the antenna, the antenna wire should be not closer than 10 feet to the masts or guy wires. It is advisable to insert insulators in the guy wires about every 15 feet. Otherwise it is possible that these wires might have a natural wavelength near that of the transmitter, in which case the guys would absorb some of the transmitted energy. Excellent insulation for the antenna is quite essential.

Pyrex insulators serve very well for this purpose, but at least two should be used in series at each end of the antenna and at any other points where insulation is needed. Glass towel bars about 18 inches long and having a glass knob on each end are inexpensive and make first-class insulators for this purpose.

The antenna should be as high as possible, and should be higher at the end farthest from the transmitter. A single wire is all that is needed, and this may well be single strand enamel insulated wire of No. 12 size. The lead-in is taken off at the end nearest the transmitter.

The counterpoise if one is used should be just as carefully constructed as the antenna. It is usually placed directly under the antenna, but if this is inconvenient may be placed almost anywhere. In any event, it should be kept as far below the antenna as possible. It is best to construct it with two or more wires which either radiate in the form of a fan from the transmitter or are spaced at least four feet apart on spreaders. In a pinch a single wire may be used for the counterpoise. In any case the counterpoise should be at least as long as the antenna, or longer if it can be conveniently arranged.

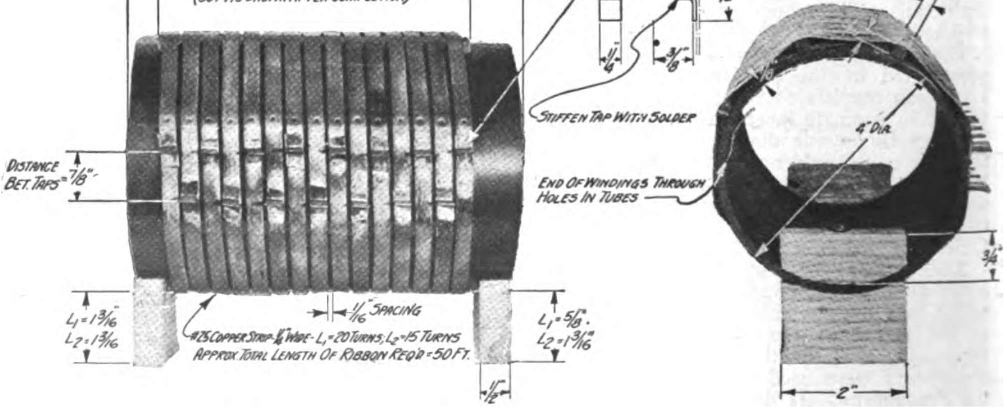
The antenna, counterpoise and lead-in wires should all be stretched taut. This is imperative, for if it is not done the transmitted signals will swing badly during windy weather—so badly as to make it impossible for anyone to read them.

The usual practice at the experimental station, where this transmitter was in use, is to tune the closed circuit of the transmitter to 40 meters and to tune the antenna circuit to 120 meters. Thus in transmitting on 40 meters use is made of the third harmonic of the antenna circuit.

The results obtained, using this method, seem to be somewhat superior to those obtained with a smaller antenna tuned to 40 meters. In this same way it is possible to use the fifth harmonic of the antenna. In that case of course the antenna will be tuned to 200 meters.

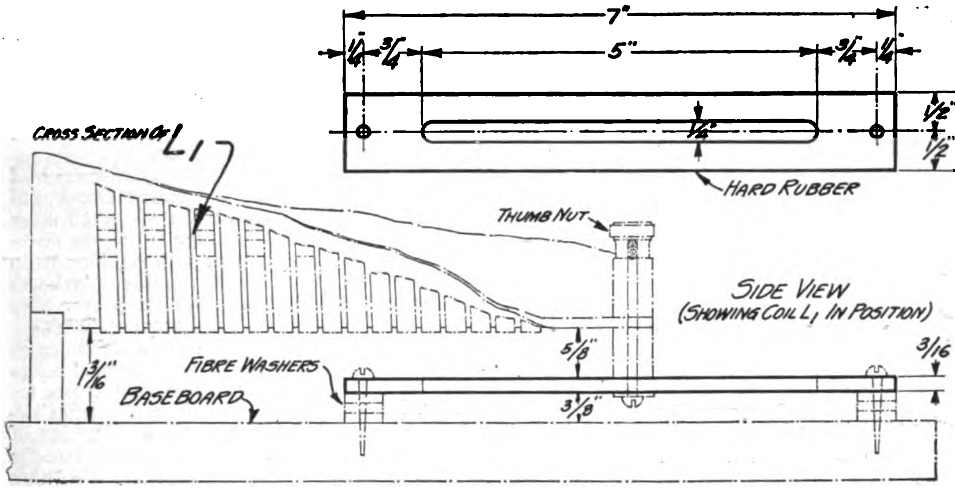
The use of the even harmonic of an antenna has not, however, been found practical. In other words, it is not advisable to tune an antenna to 80 or 160 meters if transmission is to be carried on at 40 meters.

If the antenna system is sufficiently small to have a natural wavelength in the neighborhood of 40 meters it would be necessary to use a


LENGTH OF TUBING; L1=8"; L2=6"
LENGTH OF STRIPS; L1=8"; L2=6"
(CUT AS SHOWN AFTER COMPLETION)
DETAIL OF TAP
3/16"
1/4"
3/8"
3/16"
1/8"
STIFFEN TAP WITH SOLDER
4" DIA
END OF WINDINGS THROUGH HOLES IN TUBES
DISTANCE BET. TAPS = 7/8"
3/4"
L1=1 3/16
L2=1 3/16
1/16" SPACING
#25 COPPER STRIP 1/4" WIDE - L1=20 TURNS; L2=15 TURNS
APPROX. TOTAL LENGTH OF RIBBON REQ'D = 50 FT.
L1=5/8".
L2=1 3/16"
1/2"
2"

HOW THE COILS ARE WOUND

Figure 4: *Coil L2 with its winding and mounting blocks is shown in this illustration, which gives the constructional details of the coils. Note that each turn of ribbon is punched to prevent it from sliding along the strips. The ends of the windings are secured by bending them through slots in the tube. These slots may be conveniently made by drilling several small holes as close together as possible and then cutting out the material between by means of a knife or small rat-tail file.*



THE CONSTRUCTIONAL DETAILS OF COIL L1

FIGURE 5: *The outer end of the coil L1 rests on a slotted strip of hard rubber. When the thumb nut is loosened it permits the coil to slide freely along the entire length of the slot. This provides a wide range of coupling between the two coils. The slot is cut by drilling four 3-16-inch holes as close together as possible 1 inch from the end of the strip. The material between the holes should then be cut out. A hack saw blade may then be inserted to finish the slot.*

large loading coil in the antenna circuit if it were desired at times to transmit on 80 meters. Inasmuch as such a large loading coil is not considered practical the better plan is to put up an antenna with a natural wavelength somewhere in the neighborhood of 80 meters. If this is done 80 meter transmission can be carried on using the antenna series condenser VC1 and only a few turns of the antenna inductance L1.

To transmit on 40 meters with such an antenna, the antenna series condenser is cut out of the circuit and one of the clips moved along L1 to provide the necessary inductance to bring the antenna circuit up to 120 meters. Further information on this is given later.

The two inductance coils described here were found to be a good practical size for use in conjunction with an antenna system consisting of a single wire antenna 65 feet long and 30 feet high, and a single wire counterpoise of the same length placed directly under the antenna and 20 feet below it.

Connecting up the Transmitter

The power supply equipment, key, antenna and counterpoise are connected to the transmitter as shown in Figure 1. If the meters MA and A1 are not mounted in the transmitter they should be connected in the leads from the positive high voltage supply and the antenna, respectively.

A complete description with constructional data for the power supply equipment was published in the "In the Experimenter's Laboratory" department of the January, 1926, issue of POPULAR RADIO.

The rectifier and filter for the high voltage plate supply are not absolutely essential, but their use is strongly advised for the reasons explained in the January issue.

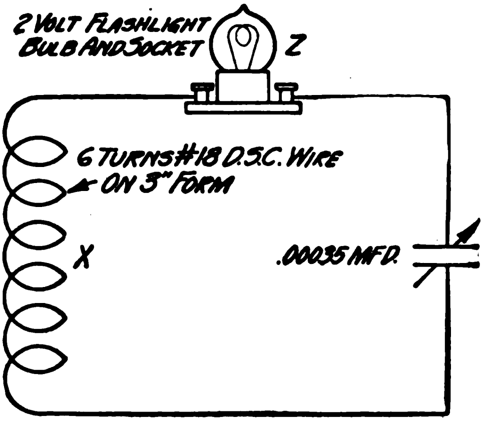
It will be noted that in Figure 1 the antenna is connected to L1 through the antenna ammeter A1, the antenna switch S1 and the variable condenser VC1. It is important that S1 be connected between the antenna and the meter and that the meter be between S1 and the condenser. In other words these instruments should appear in the circuit in the order shown in Figure 1.

All of the leads to the coils should be of flexible wire with clips at one end to facilitate connection to the coil taps. All other connecting wires in the transmitter should be plain copper wire or bus wire, anywhere from No. 18 to No. 12 in size. No. 12 bare, single strand copper wire was used in wiring up the model transmitter for the sake of greater rigidity. The connecting wires of the power supply equipment, and the wires from this equipment to the set should all be insulated wire such as is used for house wiring.

Operation of the Transmitter

Unless one has had previous experience with transmitters, it is suggested that a more advanced enthusiast be called in to help get the set started. This will save much time and experimentation. If one is not acquainted with an amateur who owns a transmitter he can probably get in touch with one through the nearest radio club. If even this is out of the question the builder will have to go his own way. This is not particularly difficult and in the end will be good experience.

A wavemeter consisting of a variable condenser, a coil and a small flashlight lamp will be extremely useful not only in putting the


2 VOLT FLASHLIGHT BULB AND SOCKET
Z
6 TURNS #18 D.S.C. WIRE ON 3" FORM
X
.00035 MFD.

A SIMPLE RESONANCE INDICATOR OR WAVEMETER

FIGURE 6: *This device works on the energy absorption principle. If it is tuned to resonance with a nearby oscillating circuit it will absorb energy from the oscillator. Thus if headphones are attached to a receiver which is tuned to a given wavelength, and the wavemeter is brought close by and tuned to the same wavelength, it will absorb enough energy to stop the oscillation in the receiver. This will be indicated by a click which may be heard in the phones. A wavemeter may be calibrated by means of this method from a calibrated receiver.*

transmitter into operation, but later. The hookup of a suitable wavemeter is shown in Figure 6.

The leads from the grid, plate and filament center tap to the closed circuit coil should all be flexible and equipped with clips to slip on the lugs on the coil winding. Connect the grid lead to the first tap (nearest the antenna coil) of the coil L2. The plate lead is connected to the tenth turn and the filament lead to about the fourth turn. For the time being the two leads to the antenna coil should be left unconnected.

The power switch may be turned on. If everything is properly connected the tube filament will light up when the rheostat R2 is turned on (if one is used).

The rheostat should next be adjusted to provide the proper filament current specified by the manufacturer's instructions which accompanied the tube. This current flow will be indicated by the meter A2. When the key is pressed, the high voltage plate current will flow and will be registered on the meter MA.

However, the transmitter may not be oscillating. This may be checked by means of the wavemeter. With the transmitter key depressed the wavemeter coil is placed about five inches or perhaps less from the coil L2 and the wavemeter dial is rotated slowly. When the wavemeter is tuned to resonance with the closed circuit of the transmitter the flashlight bulb will light up, because of the energy absorbed by the wavemeter coil when in resonance with the oscillating circuit.

If the transmitter is not oscillating, the flashlight bulb will not light up. In that case the filament lead to the coil L2 should be moved around one turn at a time until oscillation is secured. The wavelength to which the closed circuit of the transmitter is tuned can be determined by the setting of the wavemeter dial when the two are tuned to resonance.

By means of the variable condenser VC2 vary the wavelength of the closed circuit until it is somewhere in either the 40 or 80 meter bands. In making this change it may be necessary to move the filament clip again. When this circuit is tuned to a suitable wavelength connect the antenna coil into its proper place with, say, 10 turns in the antenna circuit.

Then vary VC1 until there is a deflection of the needle of meter A1. If no deflection occurs place the clips to the antenna coil closer together, leaving fewer turns in the antenna circuit. Again rotate VC1 until a deflection of the meter is obtained. During all this time the two coils should be placed fairly close together —perhaps an inch apart.

Now with the two circuits tuned to resonance and current flowing in the antenna as indicated by the antenna ammeter try readjusting the various parts of the circuit in an effort to obtain a higher antenna current reading. Try using more turns of L2 and a lower setting of VC2, moving the filament lead as needed. Also try more or fewer turns of L1, readjusting VC1 to keep this circuit in resonance with the closed circuit.

The amount of coupling between L1 and L2, regulated by sliding L1 toward or away from L2, is an important factor as well. If these coils are too close together it is probable that oscillation will be unstable.

As resonance between the two circuits is approached the antenna ammeter needle will climb and then may suddenly drop to zero. This indicates that oscillation has stopped. Or the needle may climb to a certain maximum point while the key is held down but when the key is released and again pressed the meter reading will be lower. In either of these cases, coupling between the two coils should be decreased by moving them farther apart. The antenna reading may then be lower but oscillation will at least be steady, and stability of oscillation is absolutely essential if your signals are to be heard and understood. When proper coupling has been obtained the thumb nut on the mounting of L1 is tightened to hold this coil firmly in place.

So far, so good, but it is not known definitely whether the closed circuit is tuned to resonance with the antenna circuit or with one of the harmonics of the latter. If tuned to the second harmonic of the antenna, for instance, efficiency would be low. It is important, therefore, that the operator familiarize himself with the approximate adjustment of each circuit for a given wavelength. This can be done by tuning the closed circuit to somewhere around 100 meters. This wavelength is sufficiently high so that when the antenna is tuned to resonance you will know that it must be the fundamental of the antenna circuit that is in resonance, not one of its harmonics.

If the antenna circuit cannot be brought to resonance, set the antenna circuit adjustments for maximum wavelength (using all turns of coil L1). Then vary the wavelength of the closed circuit until it is in resonance with the antenna.

When the two circuits are in resonance tune the closed circuit down to one half of this wavelength. There may or may not be a deflection of the antenna ammeter at this setting. Readjust both circuits slightly if there is no antenna current reading. In most cases a slight deflection of the antenna ammeter needle can be obtained at this second harmonic of the antenna.

Then go on down to one third of the wavelength with the closed circuit, leaving the antenna circuit tuned to 100 meters as before. At this setting a fairly substantial current flow should be indicated by the antenna ammeter. Now, if the transmitter is to be operated on 40 meters, using the third harmonic of the antenna system, tune both circuits up gradually keeping them in resonance as you go along. When the closed circuit wavelength reaches 40 meters then the antenna circuit will, of course, be tuned to 120 meters.

If the antenna is too small to be tuned as high as 120 meters it may perhaps be tuned as low as 40 meters. In that case the use of harmonics for 40 meter transmission will be unnecessary. However, it may not be possible to tune such an antenna up as high as 80 meters without considerable loading inductance in the antenna circuit.

It will be seen that there a little experimentation may be required before the right length for the antenna is found. It would be a good plan to try out a small antenna of about 30 feet in length which can be tuned down to 40 meters or up to 80 meters, and then to try a longer antenna such as the one mentioned earlier in this article, which can be tuned to 80 meters and up to 120 meters so that its third harmonic may be used for 40 meter transmission. Then for the permanent installation the antenna which proves to be best for the wavelengths on which it is desired to work may be used.

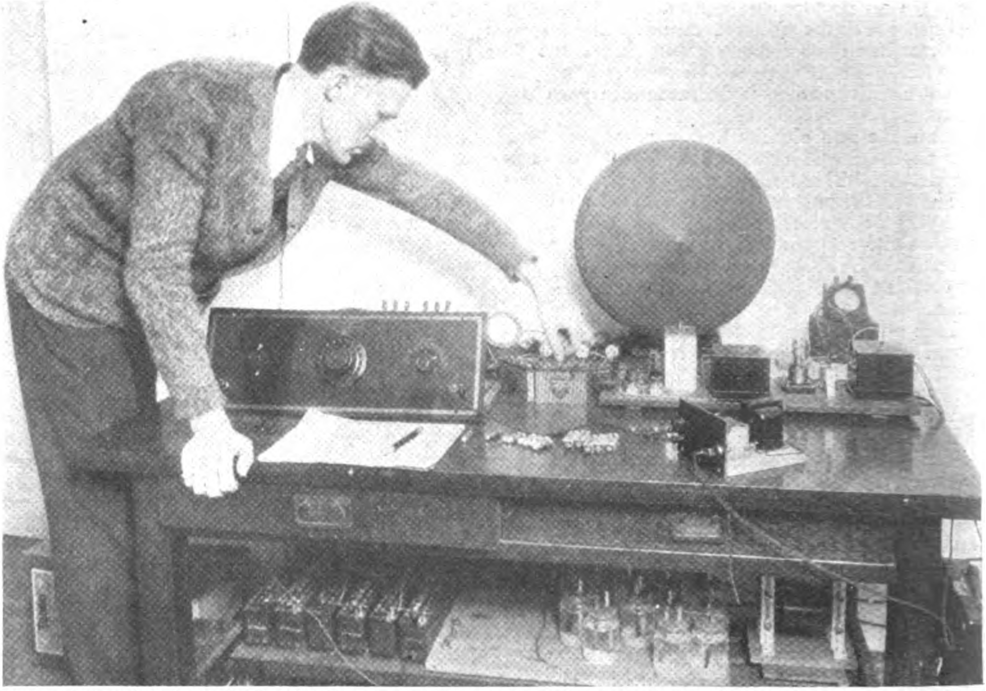
After the antenna and counterpoise are erected and the transmitter is in operation, it is well to try a water pipe or other form of ground in place of the counterpoise. In some cases the use of antenna and ground will give superior results, while in others the antenna and counterpoise will prove better. It is even found best in some installations to use both the counterpoise and ground, connecting them together at the transmitter.

Before a station is put into operation it is imperative that the government rules and regulations on amateur transmission be learned. For instance, the use of radiotelephony on wavelengths lower than 150 meters is prohibited at all times. So is the use of any modulated form of transmission, as when buzzer modulation is used. If raw AC is used for the plate supply or if half-wave rectification is used transmission is not permitted between the hours of 8 P.M and 10.30 P.M. daily, or during the broadcasting of regular church services on Sunday. Where the power supply is put through a full-wave rectifier, such as the one described in the January issue, transmission is permitted at any time desired providing no interference is suffered by neighboring broadcast fans. If your transmitter does cause interference, the quiet hours mentioned above must be observed regardless of the type of rectification used.

Above all, *it is necessary that an amateur station license be obtained from the Department of Commerce before any amateur transmitter can be put into operation. And an amateur operator's license is also required.* Full information regarding these licenses and how to obtain them may be had by writing to the radio inspector of your district, or to the Department of Commerce, Washington, D. C.

ONE OF THE WORLD'S LOVELIEST BROADCASTING STATIONS

No wonder this tiny strip of land off Miami, Florida, is called "The Wonderful Isle of Dreams." On it is located station WIOD.



From a photograph made for POPULAR RADIO

EXPERIMENTING WITH A "C" BATTERY IN THE LC-26 RECEIVER

FIGURE 1: *The effect of a "C" battery connected in the grid circuit of the last stage of the LC-26 receiver was carefully studied. An improvement in tone quality and greater economy in "B" battery consumption were obtained, as explained in this article.*

Helpful Hints for Operating the LC-26 Receiver

This additional information on the proper operation of the LC-26 receiver, together with some new data on methods of reducing plate current and improving tone quality on exceptionally loud signals, is of special interest to those radio fans who have installed this type of receiver in their homes.

By S. GORDON TAYLOR

IT was the intention of the author to call this article "Trouble Shooting in the LC-26 Receiver," but so few troubles seem to have been encountered by readers in constructing and operating the receiver that there seems to be little to "shoot."

A number of cases in which readers have reported trouble with their LC-26 receivers have been investigated personally by the author; and in every case but one the trouble was found to be outside of the receiver itself, or else in the method of operating the set. The one exception was a case where the owner had taken one of the instruments apart to see what it looked like inside and had reassembled it incorrectly.

In several of the cases which were investigated defective batteries caused the trouble; in one the loudspeaker was at fault; in another a defective tube prevented reception of distant stations with satisfactory loudspeaker volume

Two pointers were picked up, however, which may be of interest to owners of this receiver.

The first is that it is not absolutely essential that the detector "B" battery voltage be limited to 16½ or 18 volts. Some of the so called "soft" detector tubes, such as the UV-200, UX-200 and C-300 require 19½, 21 or even 22½ volts for proper operation in this receiver. If the detector voltage is too low the tube will not oscillate and the receiver will therefore not provide maximum volume, especially in receiving distant stations.

The test for oscillation is to turn the rheostat about two-thirds on, in a clockwise direction, and then to rotate the main tuning dial from zero to 100. Whistles should be heard as this dial moves past the settings for the broadcasting stations which are in operation at the time. In other words the "carrier waves" of the stations should be heard. If none are heard it is an indication that the detector is not oscillating and the process should be repeated again, this time with the detector rheostat moved about three-quarters on. In making these tests be sure that the knob of the Bradleyleak is turned in only part way, or to a point where no pressure is felt. To find this adjustment turn this knob to the right until a slight pressure is felt, then turn it back about half a turn.

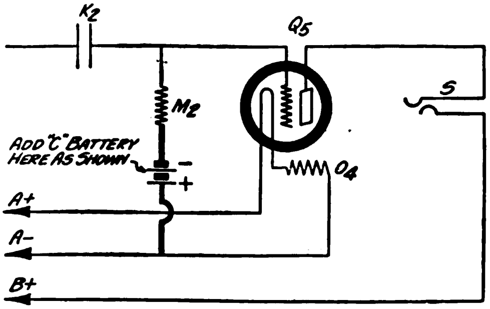
A slight click should be heard at the correct adjustment.

If the whistles are still audible, the detector tap on the small "B" battery should be moved from 16½ to 18 volts, and if there are still no results, on up to 19½ or 21 volts. These higher voltages should certainly give results unless the tube is defective. 22½ volts are rarely needed, and higher voltages never.

Several cases have appeared where builders have complained that they were unable to obtain the volume and distance which they expected, although locals were received with excellent quality and the more powerful stations were received with good volume. Investigation disclosed the fact that these fans were afraid to turn their rheostats more than half way on for fear the detector tube filament would burn out. There is no danger in turning the rheostat two-thirds "on," or even three-quarters. Where it is necessary to do this to make the detector oscillate it is probable that the Bradleyleak knob is screwed down too far or else that the detector "B" battery voltage is too low.

Turning the detector rheostat on two-thirds does not mean turning it until the arrow points to 66 on the panel. *It means turning the knob until the spring contact lever at the rear of the rheostat has traversed two-thirds of the rheostat winding.* Incidentally, it is well to attach the knob to this instrument in such a way that its arrow is parallel with the spring lever. Then the operator can tell at a glance just where the lever is in relation to the winding.

The second point is that the receiver is designed to use the UV-200 or C-300 (the "X" tubes of the same numbers are the same as the "UV" and "C" except that they have the new standard bases) as the detector in this circuit. Other tubes such as the 201-a may be used but they will not produce as good a tone



THE PROPER ELECTRICAL LOCATION OF THE "C" BATTERY

FIGURE 2: *This drawing shows only the circuit of the last tube as no advantage is gained by the use of a "C" battery in the preceding stages. The symbols used here are the same as those in the original diagram on page 497 of the December, 1925, issue of* POPULAR RADIO.

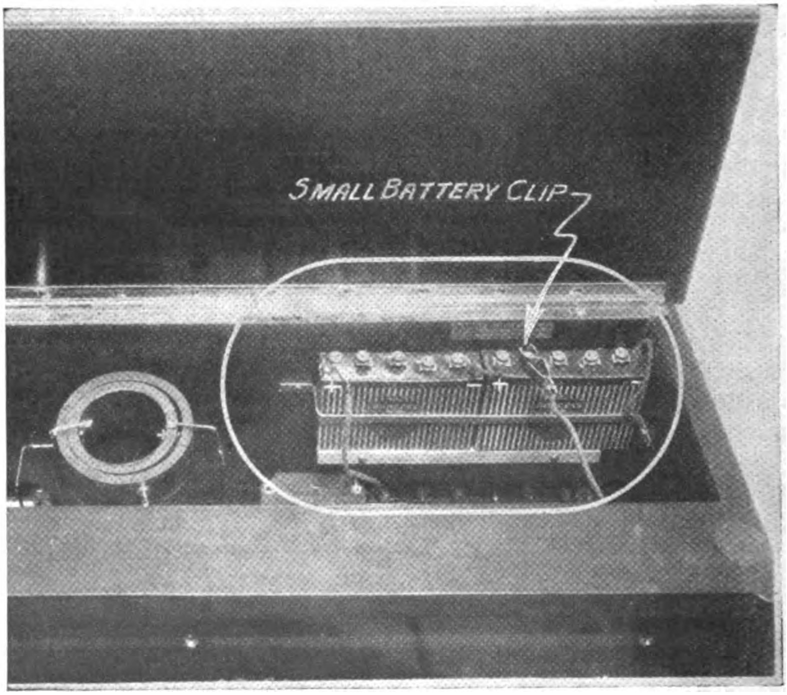
quality; and detector oscillation will be hard to control. In an emergency, a tube of this type may be used; but in such a case the detector "B" battery voltage should be reduced to probably as low as 4½ or 6 volts. Even then there will be distortion caused by too much oscillation. *By all means use a soft detector tube regardless of any advice to the contrary.*

Body Capacity in Tuning

There is no noticeable body capacity effect in tuning this receiver. The hands may be placed on the dials or anywhere on the cabinet or panel without affecting reception in the least. In every case where this complaint has been investigated it has been found that the trouble has been caused by having the loudspeaker or the loudspeaker cord within a few inches of the operator. In that case there will be a shrill whistle or hissing when the hand is placed on the tuning dial. The obvious remedy is to keep the loudspeaker and cord a few feet away from the body of the operator.

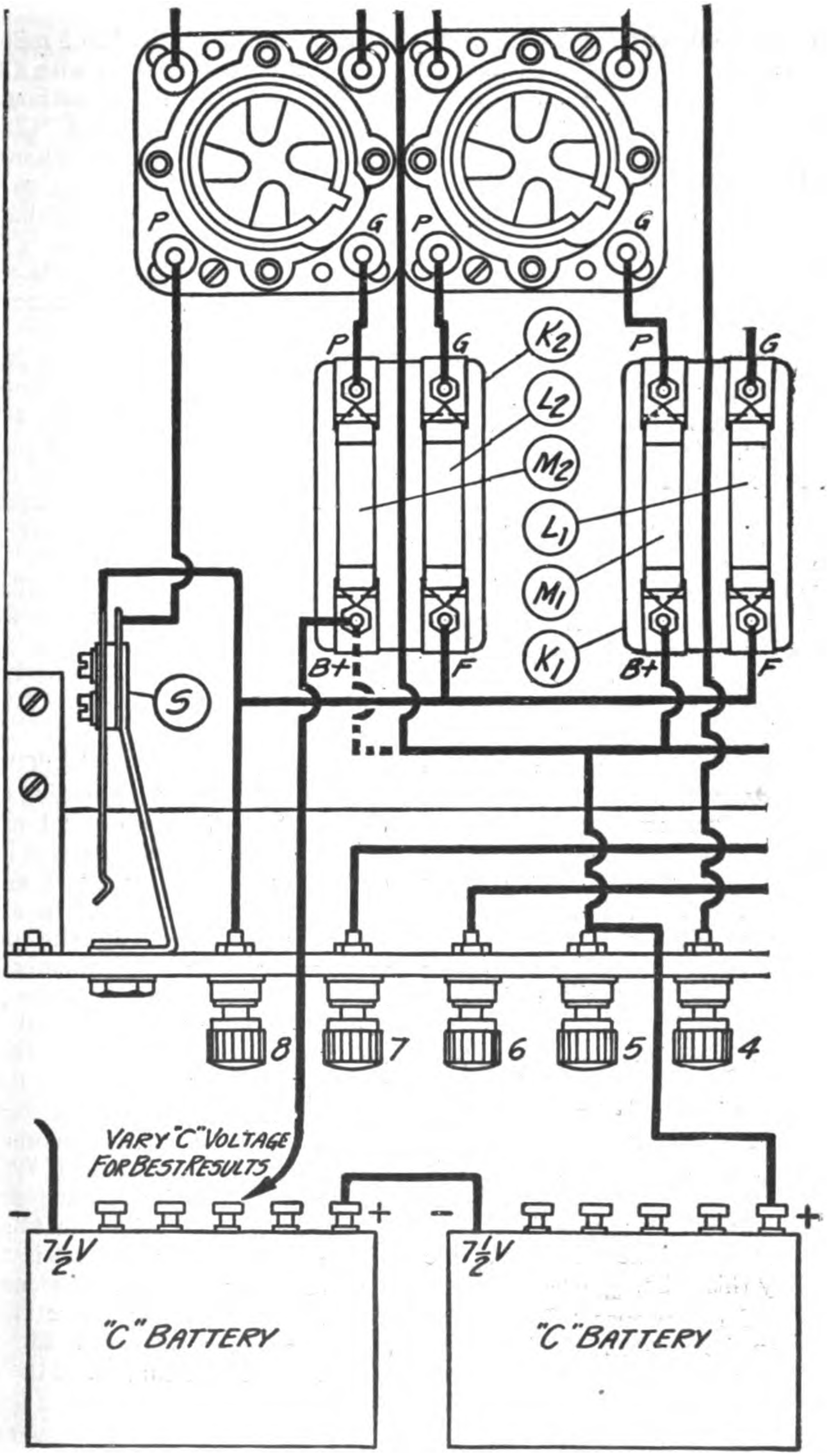
The above suggestions seem to clear up all of the "trouble shooting" data to date. More irregularities may develop in time; and in that case they, together with their remedies, will be brought to readers' attention in a later article, or in the "Experimenter's Laboratory" department of later issues.

Constant experimental work on the LC-26 receiver has been carried on by Mr. Cockaday and by the author in an effort to attain an even higher degree of perfection than that reached by the original model as described in the December, 1925, issue of POPULAR RADIO. Much of this work has been confined to the receiver itself while some has also been devoted to the accessories. The suggestions which are offered in this



THE "C" BATTERIES INSTALLED IN THE CABINET

FIGURE 3: *A small wood shelf is mounted directly on the rear wall of the cabinet. The batteries are placed on this and are held in place by a piece of 1/16 by ½-inch brass strip, bent to proper shape. A small battery clip may be used conveniently to make an easily adjustable negative connection.*



A PICTURIZATION OF THE CHANGE SHOWN IN FIGURE 2

Figure 4: *A section of the original diagram which was printed on page 505 of the December, 1925, issue of* Popular Radio, *showing the changes which must be made in connecting the "C" battery into the circuit.*

article are a result of these experiments; and each one offers some advantage in improved reception, added convenience or greater economy.

The Addition of a "C" Battery

The use of a "C" battery of proper voltage with the LC-26 receiver has been found to provide advantages in added economy of operation and in improved tone quality on loud signals. The universal comment on this receiver since its introduction last December has laid especial emphasis upon its exceptional tone quality. In this respect there seemed little hope for further improvement.

However, in carrying on experimental work in the Laboratory in an effort to reduce "B" battery consumption by means of "C" batteries, it was found that the "C" battery not only reduced "B" battery consumption considerably but actually improved the tone quality of loud signals to a noticeable degree.

When no "C" battery is used, the "B" battery current consumption of the LC-26 receiver is no higher than that of other five-tube receivers, in spite of the fact that the total "B" battery voltage used is 157½ volts. Ordinarily the amount of current drawn from the "B" batteries increases with an increase in battery voltage but the use of resistance-coupled amplification in this receiver keeps the current drain well down.

It is assumed here that a 201-a type of tube is used in the last audio stage of the receiver. If a 112 type of tube is used the current drain from the "B" batteries will be higher; but this is to be expected in view of the greater volume produced by this tube.

The use of the proper "C" battery voltage when the UX-112 tube is used in the last stage more than compensates for the added drain on the "B" batteries which results from the use of this tube. In fact the total current drain of the receiver can be cut in half. Actual measurements which have been made show a current drain of 20.5 milliamperes per hour for this receiver with a 112 tube in the last stage, but without a "C" battery. Using 9 volts of "C" battery, connected as shown in Figure 2, the current consumption is cut to 10 milliamperes. In terms of "B" battery life this means that without the "C" battery a set of "B" batteries would last approximately 170 hours if the receiver were used an average of two hours daily. With the 9-volt "C" battery in the circuit the life of the "B" batteries is extended to approximately 400 hours under the same conditions of use.

Where a 201-a tube was used in the last audio stage the average "B" battery current drawn by the receiver was 14 milliamperes. A 6-volt "C" battery reduced this drain to 9.5 milliamperes. The life of the "B" batteries without a "C" battery would, in this case, be approximately 286 hours as compared with a life of 420 hours if a 6-volt "C" battery were used.

The exact voltage for the "C" battery will vary somewhat, depending on variations in tubes and other factors in each receiver. For this reason it is impractical to recommend the exact voltage to use. In general it should be about the same as mentioned in the preceding paragraphs. If a milliammeter is available it may be connected in the negative lead to the "B" battery and used to determine the correct "C" battery voltage. With no "C" battery it will be noted that the hand of the meter fluctuates downward with modulations of the received signals. When a "C" battery is inserted in its proper place in the circuit this downward fluctuation ceases. If the "C" battery voltage is too high the fluctuation will be up instead of down. The most efficient action of the audio amplifier is that obtained with practically no fluctuation of the hand of the meter.

If no milliammeter is available it will be necessary to judge the proper "C" battery voltage by the sound of the signals. Starting with 1½ volts of

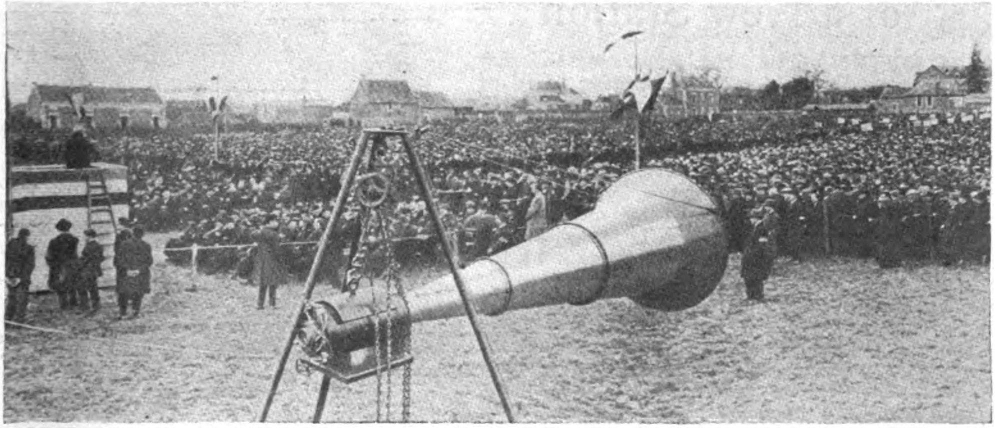
"C" battery, a broadcasting station should be tuned in with moderate strength. The "C" battery voltage should be added, 1½ volts at a time, until a point is reached where the volume starts to decrease, or the tone quality becomes impaired. It is advisable to use the highest "C" battery voltage which will still maintain the best tone quality and volume.

After the set has been operating for some time the voltage of the "B" battery will drop; and when this occurs the "C" battery voltage should be decreased also. For this reason it is well to experiment with the voltage of the "C" battery from time to time to make sure that it is being kept at the best value at all times. It might be said here that there is practically no current consumed from the "C" battery and its life should therefore be somewhere in the neighborhood of a year.

The diagram in Figure 2 shows how the "C" battery is connected in the circuit of the last tube only. Nothing is to be gained by connecting it into the other circuits. This is convenient as it requires only one changed connection in the receiver to install this additional battery whereas a good deal of rewiring would be required if the "C" battery were to be connected in the circuits of the other tubes.

Probably the most convenient location for the "C" battery is in the receiver itself as shown in Figure 3. The Burgess No. 5540 "C" battery shown in Figure 3 is handy for this use because of its compact size. Each of the small batteries shown has a voltage of 7½, tapped at every 1½ volts. Thus with two of these blocks secured on the inside of the cabinet it is possible to obtain a biasing voltage of anywhere from 1½ to 15 volts, in steps of 1½ volts.

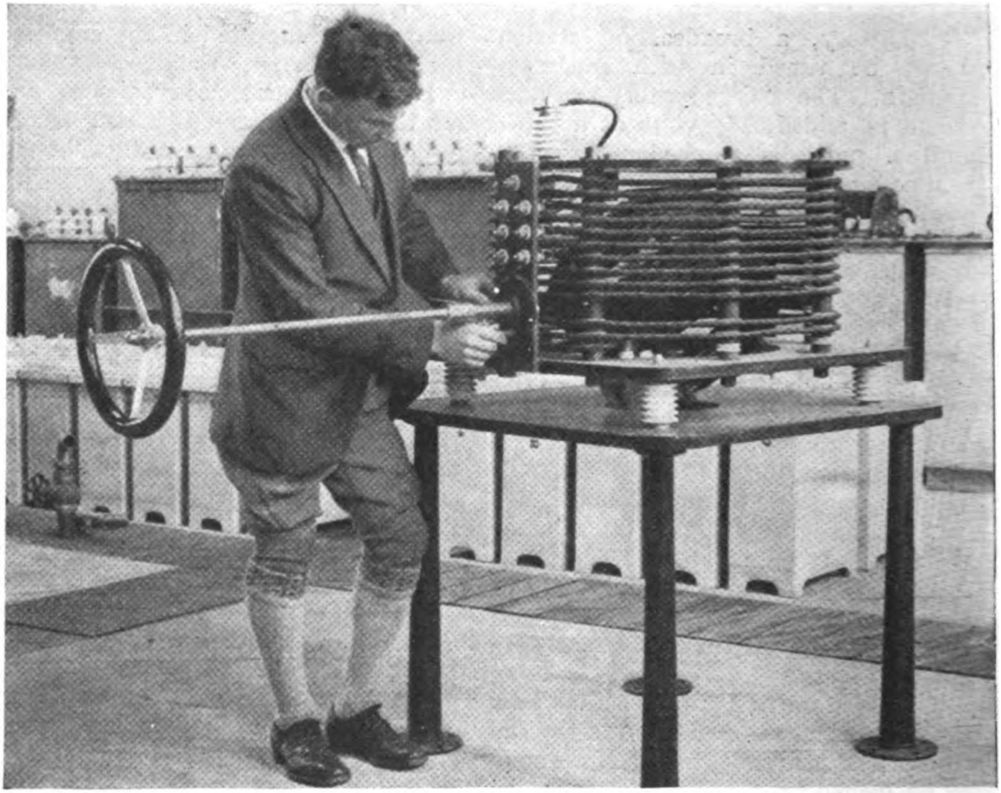
The electrical location of the "C" battery is in the grid return of the last tube, between the grid resistance, M2 (see Figure 1, page 497, December, 1925, issue of Popular Radio) and the "A" (negative "A") line. The wire which connected these two points is removed and the "C" battery is inserted in its place, with the negative terminal of the "C" battery connected to the resistance, M2, and the positive terminal connected to the "A"-line. This change is indicated in Figure 4. It is a good plan to fasten a small battery clip on the end of the connecting wire which leads to the negative terminal of the "C" battery. This will make it easier to vary the voltage.



Wide World

A LOUDSPEAKER WITH A SEVEN-LEAGUE VOICE

One of the indirect effects that radio is having upon our civilization lies in the use that is being made in other fields of apparatus developed by radio. Here, for example, is a giant loudspeaker that was heard by a crowd of 50,000 people assembled in a stadium in France.



Barratt's, London

AN OVERSIZE VARIOMETER

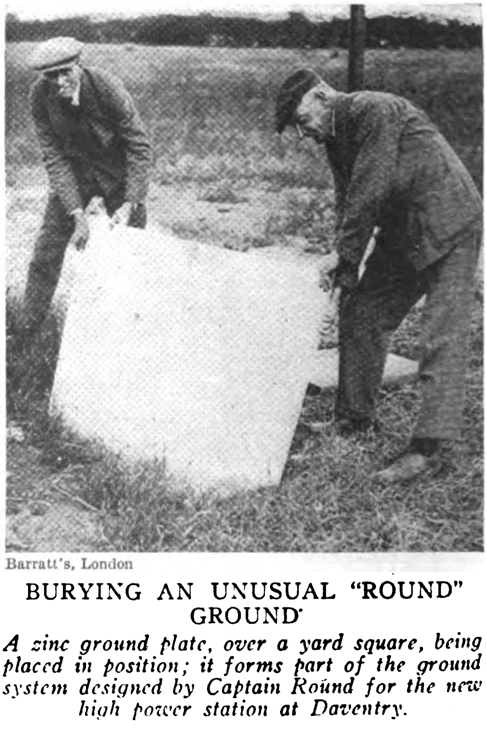
The steering wheel of a motor car has been appropriated to operate the huge variable coupling of this large antenna coil.

Two Unique Features of a New Station

ANTENNA coils which are so huge that they must be tuned with the steering wheel of an automobile and ground systems so extensive that they surround acres of meadow are two of the unique features of the new super-power broadcaster at Daventry, England.

The coupling of the antenna inductance coil (shown above) is operated by means of a shaft to which is attached a large wheel. A small dial which indicates the position of the coils encircles the shaft at the panel.

The large zinc plate shown at the right is only a small part of the comprehensive ground system devised by Captain Round, the well-known English radio engineer. Twenty-four plates, each approximately a yard square, are embedded in the earth in a circle about the buildings which house the apparatus. From each of these plates insulated wires are led to posts standing behind them. From insulators on the tops of the posts the wires converge to the transmitter house.



Barratt's, London

BURYING AN UNUSUAL "ROUND" GROUND

A zinc ground plate, over a yard square, being placed in position; it forms part of the ground system designed by Captain Round for the new high power station at Daventry.

The obverse of the medal; this original is two-and-one-half inches in diameter.

The reverse; the name of each recipient will be engraved in the space provided.

THE POPULAR RADIO

Medal for Conspicuous Service

TO every radio amateur; to every amateur experimenter and broadcast listener, who is instrumental in alleviating human suffering or saving human life, directly or indirectly through the medium of radio, recognition will hereafter be extended in the form of a medal that shall be known as "The Popular Radio Medal for Conspicuous Service."

This medal is unique within the realms of radio in that it shall be awarded, not for scientific achievement or invention, but for service to humanity; for bringing aid in time of peril, within the territorial confines of the United States and its possessions and in its waters.

It shall be awarded without discrimination to all amateurs—men, women or children, of any race, nationality, color or creed—through whose prompt and efficient action radio is utilized to perform an essential part in rescue work. The awards shall be restricted to nonprofessionals only.

To insure a fair and unbiased consideration of all claims, a Committee of Awards has been appointed that includes five distinguished citizens of international fame.

To assist this Committee of Awards, an Advisory Committee has been appointed that numbers among its members some of the most eminent citizens of the United States, including representatives of many of our most distinguished institutions. These gentlemen have been carefully selected not only because they themselves are interested in public service, but also because many of them represent important bodies and are consequently in positions to know of the activities of individuals within their spheres and to make recommendations that are based upon personal knowledge of the achievements of candidates for the medal.

The Popular Radio Medal for Conspicuous Service has been designed by the well-known artist, Walter D. Teague. It is two and a half inches in diameter in size, and is cast in monumental bronze.

The conditions under which the medal will be awarded are here specified:

1. The medal shall be known as the Popular Radio Medal for Conspicuous Service.

2. The medal shall be awarded, without discrimination as to sex, age, race, nationality, color or creed, to those radio amateurs, radio experimenters, broadcast listeners and other non-professionals through whose prompt and efficient action radio is utilized to perform an essential part in the alleviation of human suffering or in the saving of human life within the territorial confines of the United States and its possessions, or in the waters thereof.

3. The medal shall be awarded by a Committee of Awards that shall not exceed five in number. No member of this Committee shall be an employee, officer or stock holder of Popular Radio, Inc., nor shall any such employee, officer or stockholder have a vote in the deliberations of the Committee.

4. An Advisory Committee, which shall cooperate with the Committee of Awards and which shall be particularly charged with the responsibility of making recommendations for awards of this medal, shall be made up of men and women who, because of their interest in the public welfare or because of their connection with institutions that are consecrated to public service, are in positions to bring to the attention of the Committee of Awards the exploits of candidates who are within their own special fields of activity.

5. The medal will be awarded for services rendered since Armistice Day, November 11, 1918.

6. Recommendations for awards may be submitted to the Committee of Awards at any time and by any person. Every recommendation must contain the full name and address of the candidate, together with a detailed account of the accomplishment on which the proposed award is based, and must be accompanied by corroboratory evidence from persons who have first-hand knowledge of the circumstances and whose statements may be verified to the satisfaction of the Committee of Awards.

7. The medal will be awarded to as many individuals as qualify for it and at such times as the Committee of Awards may authorize.

8. All considerations not specified herein shall be left to the discretion of the Committee of Awards.

All communications to the Committee of Awards may be addressed to—

THE SECRETARY OF THE COMMITTEE OF AWARDS, POPULAR RADIO MEDAL FOR CONSPICUOUS SERVICE, 627 WEST 43rd STREET, NEW YORK.

The Committee of Awards

of the Popular Radio Medal for Conspicuous Service

Hiram Percy Maxim, *President of the American Radio Relay League.*

E. F. W. Alexanderson, *Chief Consulting Engineer of the Radio Corporation of America.*

Major General Charles McK. Saltzman, *Chief Signal Officer of the Army.*

Rear Admiral W. A. Moffett, *Chief of the Bureau of Aeronautics, U. S. Navy.*

Dr. John H. Finley, *publicist and journalist.*

Secretary: Dr. E. E. Free.

Advisory Committee

Senator James W. Wadsworth, Jr., *of New York.*

Hon. John Barton Payne, *Chairman, American Red Cross.*

Adolph Lewisohn, *publicist.*

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Dr. J. McKeen Cattell, *President, American Association for the Advancement of Science.*

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Farley Osgood, *Past President, American Institute of Electrical Engineers.*

C. S. Grunsky, *President, American Society of Civil Engineers.*

Dr. Dayton C. Miller, *President, The American Physical Society.*

W. L. Abbott, *President, the American Society of Mechanical Engineers.*

W. J. Holland, *President, Carnegie Hero Fund Commission.*

George K. Burgess, *Director, Bureau of Standards.*

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Daniel C. Beard, *Chairman, National Court of Honor, Boy Scouts of America.*

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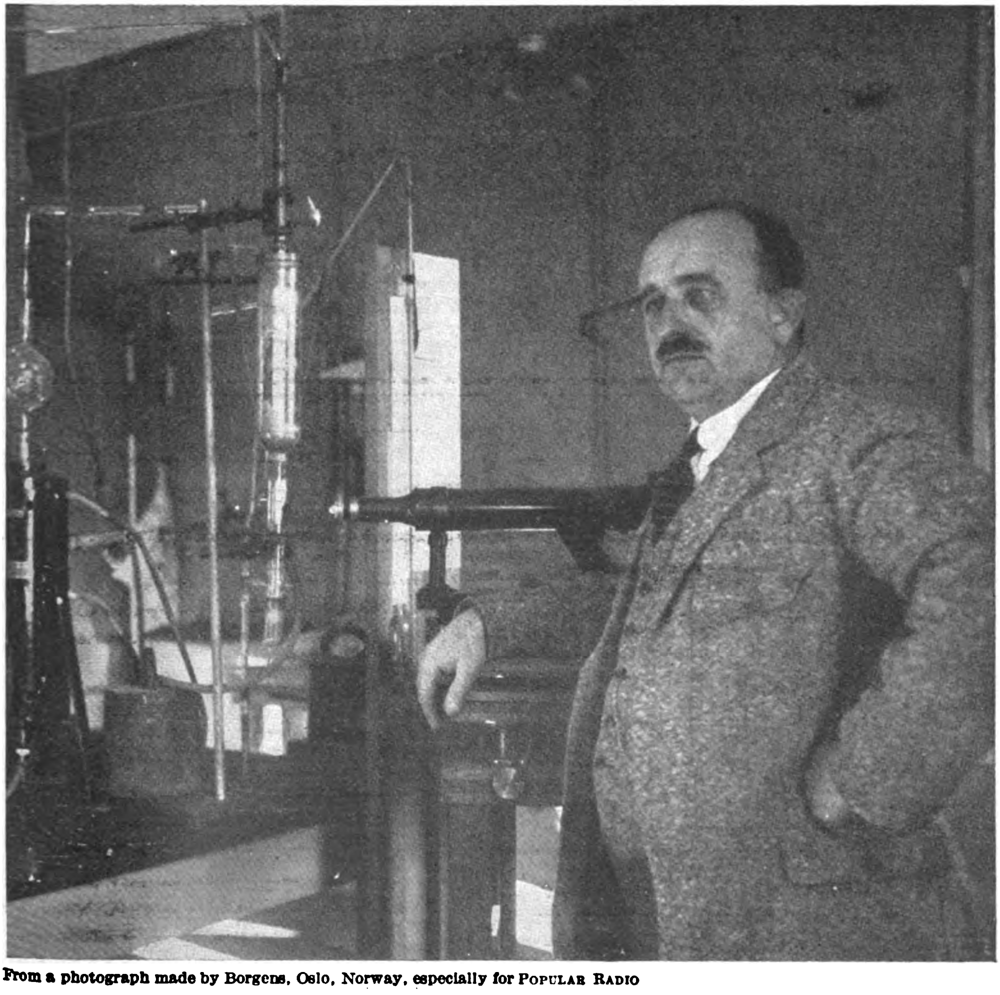
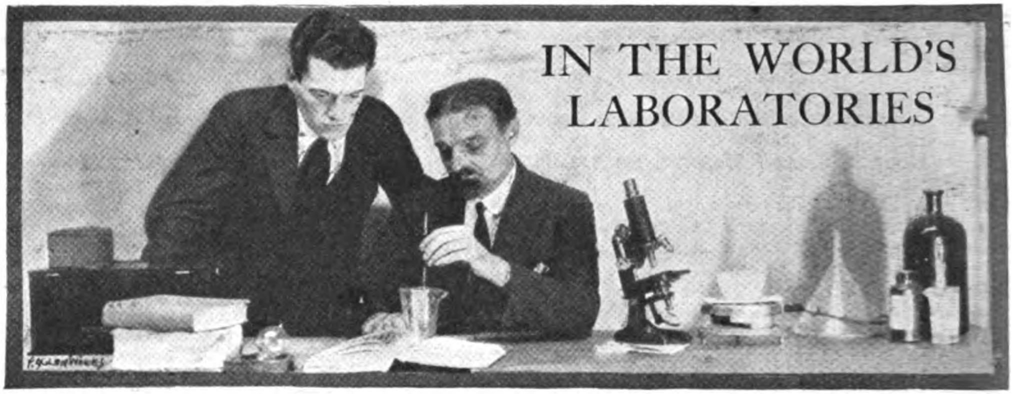
W. E. HARKNESS, *Vice-President, American Telephone & Telegraph Company.*
WILLIAM L. SAUNDERS, *President, United Engineering Societies.*
BRIG. GEN. J. R. QUIGG, *Commander, the American Legion.*
JOHN H. MOSS, *President of Kiwanis International.*



From a photograph made by Borgens, Oslo, Norway, especially for POPULAR RADIO

WHAT EFFECT DOES THE AURORA BOREALIS HAVE ON RADIO RECEPTION?

Among the distinguished physicists who are seeking the answer to this important question is Prof. Lars Vegard of Norway, who is shown above with the apparatus used to obtain the green spectro line of the aurora from frozen nitrogen gas. What has already been learned about this subject of interest to all radio fans will be told in POPULAR RADIO *for May.*



CONDUCTED BY DR. E. E. FREE

Have "Brain Waves" Been Discovered?

THE scientific world, to say nothing of that part of the world which remains blissfully unconscious of science, continues to nurse the hope of identifying some kind of human radiation, some "ray" which may be correlated with the mysterious phenomenon of thought and which may be used, perchance, to provide a reasonable basis for the supposed and cherished instances of thought transference or "telepathy." Radio has been invoked many times as the medium of this transference. But, as the properties of radio waves become better understood, this continues to seem less and less probable. The current idea, nowadays, seems to be that there is some unknown kind of radiation lurking somewhere in the less explored parts of the ether-wave spectrum. Even this, it must be concluded, is extremely doubtful.

In a recent series of papers, M. Francis Marre, of Paris, summarizes the claims made for the reality of some such human radiation.[*] In England, Mr. C. Russ (not to be confused with Dr. Sidney Russ, the well-known biophysicist of London) has made some stir by announcing his supposed (but very doubtful) discovery of an instrument which can be deflected by the power of the human eye. Much more important than this is the fact that Dr. Ferdinando Cazzamalli, Professor of Nervous Pathology in the University of Milan, Italy, has obtained what he believes to be experimental evidence of the "broadcasting" of radio impulses by the human brain, especially in states of extreme emotion and in abnormalities of the "psychic" variety.[†]

Whether or not one agrees with the conclusions reached by Dr. Cazzamalli, it is necessary to applaud the care and seriousness with which he has attempted to obtain unmistakable experimental evidence of radio emanations from the brain. The experiments were conducted inside an airtight room, built of carefully soldered sheets of tern plate (sheet iron covered with a lead alloy). This room contained a cot for the patient, a chair and the radio detecting apparatus. Air was provided through filters composed of iron filings and grounded. The metal sides of the room were thoroughly grounded also. If necessary, food could be introduced through a two-compartment metal trap, also grounded. These precautions were necessary in order to keep out stray electromagnetic disturbances. That they were successful was indicated by the fact that a radio receiver inside the sealed room picked up no disturbance whatsoever, not even any static.

The radio devices used in the experiments were of several types, ranging from a simple crystal detector to vacuum-tube receivers provided with two stages of audio-frequency amplification. From the viewpoint of the radio engineer, Dr. Cazzamalli's descriptions are not very complete; but it appears that none of the receivers employed would have possessed extreme sensitivity. Nevertheless, sounds were heard in the receivers whenever the patient, inside the metal room, entered any abnormal or emotional mental state. There seemed to be certain correspondences between the nature of the mental state and the character of the sounds, although Dr. Cazzamalli is properly conservative in asserting this as a definite conclusion.

This is, undoubtedly, an important and valuable experiment. It appears to be the first time that a human being and a radio receiver have been isolated together inside a thoroughly grounded cage. There is now no doubt that under these circumstances disturbances of some kind can be picked up by the receiver. Dr. Cazzamalli has indubitably done this. But can we be so sure that the disturbances are "brain waves?"

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[*] "Essays on the Radiation of the Organism" (in French), by Francis Marre. *Radio-Electricité* (Paris), vol. 6, pages 306-307 (August 25, 1925), pages 322-323 (September 10, 1925), and pages 342-343 (September 25, 1925). See also an earlier contribution by M. Paul Lambert, under the same title, to which M. Marre acknowledges indebtedness, which was published originally in *L'Electricité pour Tous* (*Brussels*), January 15, 1925, and republished by *Radio-Electricité*, vol. 6, pages 463-464 (December 25, 1925).

[†] Dr. Cazzamalli's experiments were announced last summer in the *Revue Metapsychique* (Paris) and were noted in the American newspapers during the week beginning August 16, 1925. His paper has now been translated into English by Mr. J. Malcolm Bird, assisted by Mr. Austin C. Lescarboura, as radio expert. It appears as: "Telepsychic Phenomena and Cerebral Radiations," by Ferdinando Cazzamalli. *Journal of the Society for Psychical Research* (New York), vol. 20, pages 1-17 (January, 1926). POPULAR RADIO is indebted to Dr. Cazzamalli for some additional information concerning his experiments.

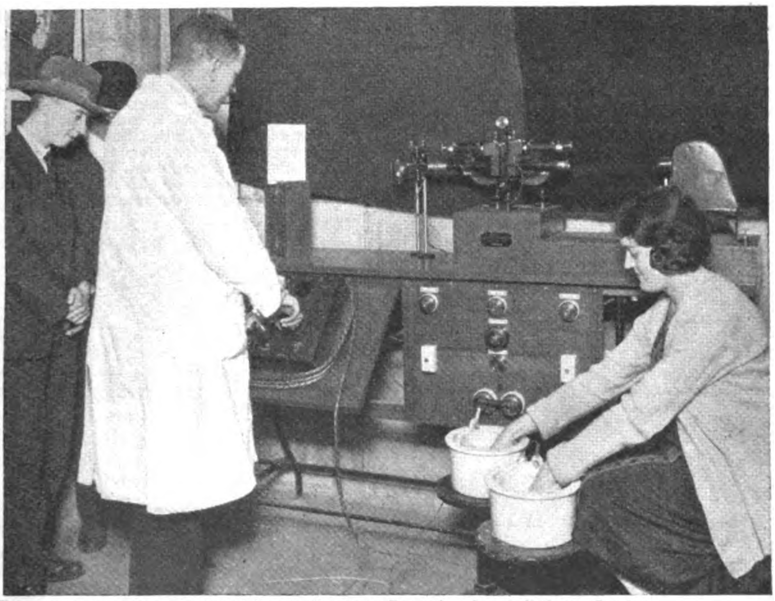
All nerve action, it is true, is certainly of electric character. It is probable that it sends out, as do all electric changes, some variety of ether-impulse; possibly some kind of wave, possibly some quickly-damped impulse more like that created by a sharp and transient electric spark. With these conclusions all physicists and physiologists will agree. But, unfortunately, these electric reactions in the nervous tissues, including the brain, are not the only electric changes which go on in the living human body. Every beat of the heart causes an electric change. That is how the familiar medical instrument, the electro-cardiograph, operates. The corpuscles of the blood are electrically charged. Every time that a muscle contracts, including the involuntary and unconscious contractions of the muscles of the stomach and of other internal organs, an electric change occurs. An ether impulse of some kind is sent out, undoubtedly, into the surrounding space. It seems quite possible that it was some of these bodily reactions which Dr. Cazzamalli's apparatus detected, not any "thought wave" from his patient's brain.

The difficulty in detecting the possible "human radiation" by radio is not that none exists, it is that too much exists; too many kinds of impulses are coming out all the time from the living, active human body. This is no criticism of Dr. Cazzamalli. He has taken an important first step. It is to be hoped that the experiments will be continued and extended as rapidly as possible, both by Dr. Cazzamalli and by others.

What is needed, of course, is not more sensitive receivers but more selective ones. Probably any good radio receiver, properly shielded from outside interference, will duplicate what Dr. Cazzamalli has observed. The problem is to sort out the impulses of different kinds, to separate the heart-waves and the stomach-waves and the muscle-waves and so on, from any possible brain-wave that may be there. The plight of the present brain-wave searcher is like that of a man with an untunable crystal receiver set up in some radio bedlam such as our great cities have now become.

Radio Ills from Sunspots

If there remained any radio experts who doubted the effects of the condition of our sun on terrestrial radio, they must have been convinced during the International Radio Tests of the week of January 24, 1926. It happened that at that time there were two active groups of spots on the sun. These were easily large enough to be seen by the naked eye, protected, of course, by a bit of smoked glass. During that same week the aurora was unusually active



From a photograph made especially for POPULAR RADIO by Campbell-Gray, London

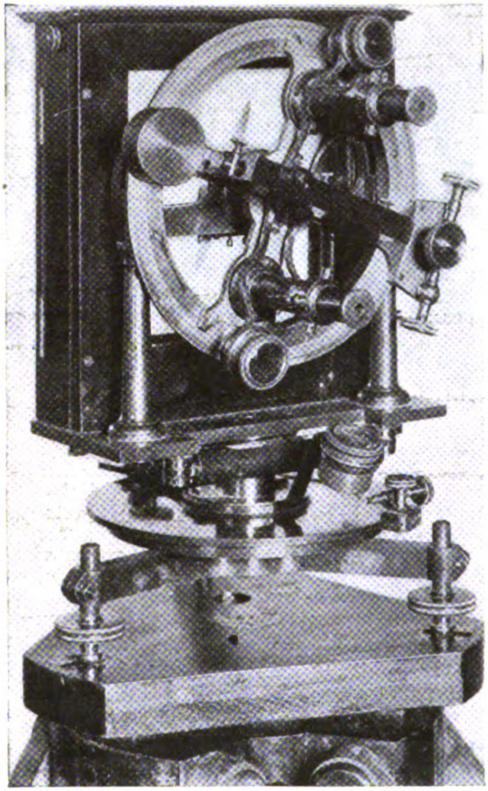
MEASURING ELECTRIC CURRENTS FROM THE HEART BEAT

One of the chief difficulties about detecting electric waves from the brain is that every muscle in the body, including that of the beating heart, produces electric changes. The instrument shown here is the electro-cardiograph, used to detect these changes. The girl's hands, dipped into bowls of salt water, make the contacts by which the heart's electricity is communicated to the recorder on the table. This photograph is published by special permission of the British Empire Exhibition Committee of the Royal Society.

and severe magnetic storms occurred. That week marked, also, the practical failure of the International tests. Radio transmission across the Atlantic was consistently worse than in many weeks in the spring and fall.

The fact that an unusual number of spots was appearing on the sun became obvious in the first week of November. The group then visible disappeared around the edge of the sun on November 20 and did not reappear. By mid-December, however, another large group had appeared and the sun remained unusually bespeckled after that time. At the time of the total eclipse, on January 14, the observers in Sumatra reported both sunspots and prominences as unusually and unexpectedly numerous. Terrestrial symptoms began on December 27 and 28, both of these dates being marked by magnetic disturbances of moderate intensity. These disturbances continued at intervals until January 26, on which day occurred one of the most violent magnetic storms on record, with corresponding deterioration of radio communication.

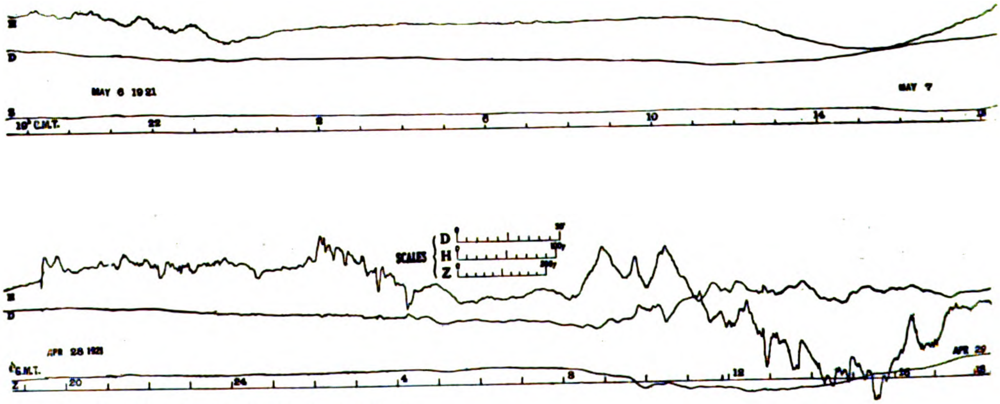
By "magnetic storm" is meant an occasion on which the elements of the earth's magnetism show sudden and relatively violent alterations. The direction in which the compass needle points may swing to the east or to the west by a whole degree, or even more. The angle of "dip," which means the normal inclination of the magnetic lines of force to the surface of the ground, may alter also. The intensity of the earth-magnetism, as measured by a magnetometer, suffers simultaneously from the same disturbances.* That these magnetic symptoms



U. S. Coast and Geodetic Survey

A DIP CIRCLE

This is a delicate magnetic compass, so arranged that its needle measures the inclination of the earth's magnetism to the horizontal. This inclination, called the "dip," changes during the magnetic storms which so disturb radio.



From Special Publication No. 117, U .S. C. & G. S.

A MAGNETICALLY QUIET DAY AND A STORMY ONE

Curves are given for two days, a quiet day above and a disturbed day below. ***The three curves*** *for each day indicate, respectively, the magnetic declination,* ***the intensity of the magnetic*** *force and the inclination of this force to the earth's* ***surface.***

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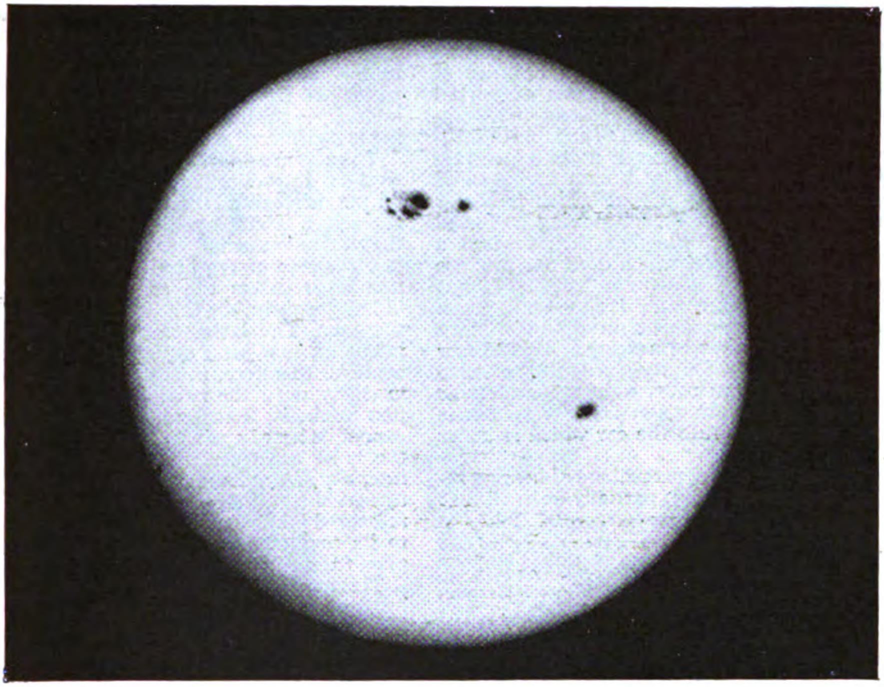
*An admirable general discussion of the earth's magnetic field, its variations and the means of measuring its elements is contained in "The Earth's Magnetism," by Daniel L. Hazard, 52 pages, 1925, published as Special Publication number 117 of the United States Coast and Geodetic Survey and obtainable for fifteen cents from the Superintendent of Documents, Washington, D. C. Every radio fan interested in the effects of earth magnetism on radio should obtain and read this document.



William Henry

DISTURBERS OF THE INTERNATIONAL RADIO TESTS

This picture shows the remarkable sun spots of January 24, 1926. The larger spot was vast enough to have ingulfed a dozen whole earths. Magnetic disturbances connected with the violent solar storms creating these spots caused severe interferences with the international broadcasting tests late in January.

are merely results of a more widespread electromagnetic disturbance as indicated by the simultaneous occurrence of powerful stray currents in long telegraph lines and similar wires, sufficient, in many instances, to paralyze telegraphic communication for minutes or even for hours.

Just how these terrestrial magnetic effects are related to what is going on in the sun is not known, although a general correspondence in time between the terrestrial magnetic storms and an unusual frequency of sun spots has been recognized for many years and is universally admitted. A sun spot consists, the astronomer's believe, of a vast whirling storm in the sun. It is much like a terrestrial cyclone, although far larger. We know, too, by actual observation of the light from sun spots, that vast magnetic forces are at work in them, forces great enough to modify the light-giving power of the atoms caught therein. Possibly these magnetic (and undoubtedly electric) forces in the spots send out electromagnetic waves of some kind which affect the magnetic field of the earth. Or perhaps the messengers are streams of electrons or ions, shot out from the solar atmosphere when this atmosphere is so tremendously disturbed as it is by a vast sun-spot storm perhaps a hundred thousand miles in diameter.

Whatever the mechanism, it is beyond question that spots on the sun mean trouble for telegraphers and for radio listeners here on earth. Radio transmission is dependent, we now know, upon the electric condition of the atmosphere and upon the nature and intensity of the earth's magnetic forces.* Both of these are affected, very powerfully, by the disturbances, whether electronic or radiant, which are sent out from a stormy sun. Our dependence upon the sun for light and heat and power and food is well known. It is now apparent that we are dependent on it, also, for the good or bad quality of radio.

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*For the effects of the magnetic forces of the earth on radio transmission see: "How Earth Magnetism Affects Radio Waves," by H. W. Nichols and J. C. Schelleng, POPULAR RADIO for October, 1925, pages 309-316; also, "Alexanderson's Theory of Twisting Waves," POPULAR RADIO for November, 1925, pages 461-463.

Trailing Noises With a Radio Apparatus

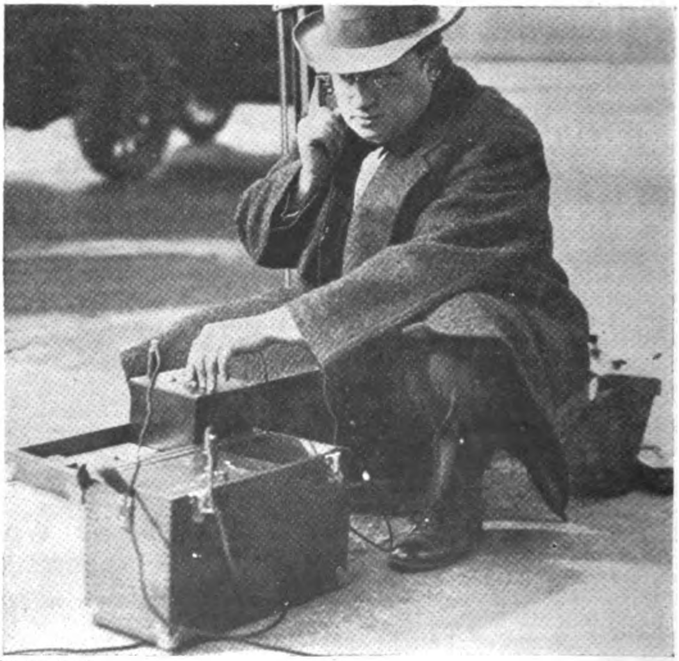
ONE of the latest services of radio science to other scientific inquiries is the apparatus, recently developed and applied, by which the loudness of noises of any kind may be measured and reduced to definite quantitative units. This apparatus was applied some months ago to the measurement of the amount of noise produced by a moving automobile. More recently, the apparatus has been used to make a "noise survey" of the streets of Manhattan and of Brooklyn.

The development began with the audiometer, an instrument devised by Dr. Harvey Fletcher, of the Bell Telephone Laboratories, for the purpose of measuring the hearing abilities of the human ear, especially in cases of partial deafness.* This audiometer consists of a combination of vacuum-tube circuits capable of feeding into a telephone receiver notes of certain given audio frequencies and with any desired intensity, from zero to a tone which is louder than most people can bear. Having perfected this instrument, Dr. Fletcher then devised a smaller, portable form, which does not produce pure tones each of a definite frequency, but merely a single buzzer note, designed to contain most of the audio frequencies present in ordinary sounds and important in hearing. This buzzer note may be attenuated, by a potentiometer, so that any desired intensity, over a considerable range, may be fed into a standardized telephone receiver and thence into the ear which is under test.

For the testing of the percentage of hearing remaining to a person who is partially deaf, all that is necessary is to determine the attenuation of the buzzer note which can be introduced without making the note inaudible. If even the loudest note is unheard, the deafness is considered complete. If the note can be heard at its lowest intensity—the most complete attenuation—hearing is considered perfect.

To measure noise with this device a modification is introduced. Instead of an ordinary telephone receiver, fitting closely against the ear, a receiver is employed which has an offset, so that there is a small space between the receiver and the side of the head. Noise from the surroundings enters the ear through this space. Simultaneously, the tone from the receiver enters the ear. The latter tone may be adjusted in intensity, as just explained. The operation consists, therefore, in adjusting this buzzer-note intensity until the noise from the surroundings just masks it; that is until the buzzer note just cannot be heard against the noise. The note and the noise are then assumed to have the same intensity, an assumption which is found correct by actual test, provided only that the noise being measured is substantially similar in character (as to its component frequencies) to the tone supplied from the buzzer.

This method of measuring the intensity of noise has been applied to automobile noise by B. J. Lemon and H. Clyde Snook and to the general street noise of New York City, in the investigation already mentioned, which was made by the



International

HOW STREET NOISE WAS MEASURED IN NEW YORK

The buzzer circuit of the audiometer is inside the larger wooden box. The smaller box, resting on the lid of the larger one, is the potentiometer, used to attenuate the buzzer note, as in an audibility meter. The telephone receiver, pressed to the operator's ear, permits the street noise to enter the ear together with a note of known intensity from the buzzer circuit.

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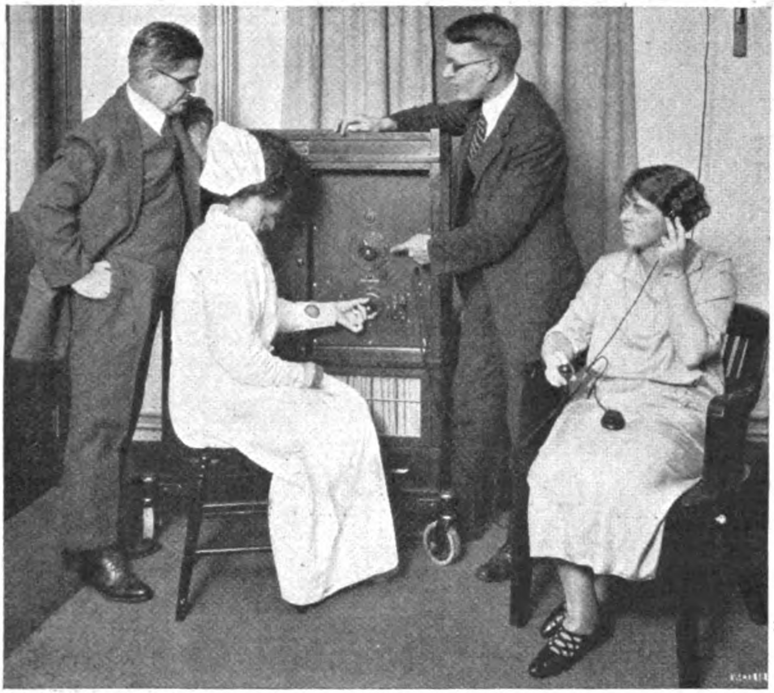
*See POPULAR RADIO for December, 1924, pages 620-622. For a full account of the audiometers, their theory and uses see: "Audiometric Measurements and their Uses," by Harvey Fletcher, *Transactions of the College of Physicians of Philadelphia*, 1923, 13 pages; and "Physical Measurements of Audition and their Bearing on the Theory of Hearing," by Harvey Fletcher, *Journal of the Franklin Institute* (Philadelphia), vol. 196, number 3, (September, 1923), 38 pages; both reprinted by The Bell Telephone Laboratories, Inc., New York.



Bell Telephone Laboratories

THE MOST COMPLETE FORM OF AUDIOMETER

This instrument, devised for the testing of hearing, uses vacuum-tube oscillating circuits to produce tones of fixed pitch and known intensity. The patient, seated at the right, records the intensity which she can just hear. Thus the sensitivity of the ear for various pitches is determined. Standing behind the patient is Dr. Harvey Fletcher, of the Bell Telephone Laboratories, who perfected the audiometers, including the one used for noise measurement.

Forum, a magazine of that city.*† The apparatus and its use for noise measurement were described by Mr. Snook before the Society of Automotive Engineers in June, 1923, and again before the New York Electrical Society, February 3, 1926.

The most striking conclusion from the noise survey of New York City is that practically all of the city noise is produced by the traffic on the streets, with the automobile truck ranking as the greatest contributor. As might have been expected, the noise is local in distribution; the back rooms of a house may be very quiet, even though the house fronts on a very noisy street. In terms of physical units, the quietest places in the city have an average noise intensity of approximately .001 dyne per square centimeter; the noisiest places reach an average of about 20 dynes per square centimeter, a variation of twenty thousand times. The noise of 20 dynes per square centimeter means, in terms of human hearing, that about half the normal sensitivity of the human ear is lost where that level of noise prevails.

The most interesting feature of these new methods and tests (for the radio engineer, at least) is what they suggest for the future. Noise is increasing in our cities; it is increasingly annoying. There is more and more demand for noiseless automobiles, noiseless offices, quieter houses, machinery that is less ear-splitting. One can scarcely doubt that there will be, before many more months, a new profession of noise engineer. The tools of this profession will be radio tools; its technique will be, essentially, the technique of the radio engineer. It will merely be audio-frequency work instead of radio-frequency work. The path blazed by the Bell Telephone Laboratories, in the persons of Mr. Snook and Dr. Fletcher, will be followed, we may be sure, by many of the radio fraternity.

We must not forget, however, an important caution. The science of sound has been a backward one for a generation. Other sciences have outstripped it. Many of its basic facts are unknown or are known only imperfectly. These facts are being discovered or corrected quite rapidly. They will soon be available, just as the facts about city noise have become available. In the meantime, guessing is dangerous. The fact that acoustic engineering is likely to call for

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*See the important paper "Automobile Noise Measurement," by H. Clyde Snook. *Journal of the Society of Automotive Engineers*, vol. 17, number 1 (July, 1925), 29 pages, reprinted by Bell Telephone Laboratories, Inc., New York City.

†"How Noisy is New York," by E. E. Free. *The Forum* (New York), vol. 75, number 2, pages xxi, xxii and xxiv of the illustrated section (February, 1926). Newspaper accounts, with some additional data, were published in the New York Herald-Tribune for January 15, 1926, and in the Brooklyn (New York) Eagle for January 21, 1926.

men and for answers should not induce ill-prepared enthusiasts to rush into it too rapidly or to promise or attempt too much.

A New Radio System for Locating Ships

AN ingenious combination of sound waves and radio waves has been perfected by the United States Coast and Geodetic Survey in order to locate the exact position of a survey ship off the coast, even when the coast line is hidden by fog, haze or the smoke of forest fires ashore.* Under normal conditions the location of a vessel engaged, for example, in making precise soundings for shoals and reefs, is determined by taking the direction of two or more visible points on the shore, so that the ship's position may be fixed on the chart by what surveyors call "triangulation." This requires good vision of the shore stations. When they cannot be seen the use of this method is impossible.

The new method obviates this difficulty. Visibility of points on shore from the surveying ship is not necessary and only a stiff gale will cause the suspension of the survey work. "The measurement is made," says the Survey, "by recording the speed of a sound wave from ship to shore and then converting it into distance," a conversion which is quite easy when the speed of sound in sea water is known. "The sound is produced," the Survey's statement continues, "by the detonation of a time-fuse bomb of T. N. T., which is dropped from the vessel while under way. The sound of the explosion is picked up on board ship by a hydrophone (a microphone for under-water service) which converts the pressure variations of sound waves into variations of electric current. These variations are amplified to operate a relay, through which the instant of explosion is registered on a strip of moving paper. The ticks of a chronometer are also recorded on this strip.

"The sound wave from the explosion is also picked up on shore by a hydrophone planted on the bottom of the sea and connected to the shore station. The sound impulse is amplified to operate a relay, which, after a predetermined interval, starts a radio transmitter to sending out a code message for that particular station. Reception of this message on the vessel is recorded on the chronograph strip. After the known lag at the shore station is subtracted, the travel time [for the sound wave in the water] is converted into distance. * * * * Coast and Geodetic Survey vessels have worked successfully 206 miles off shore by this method." If

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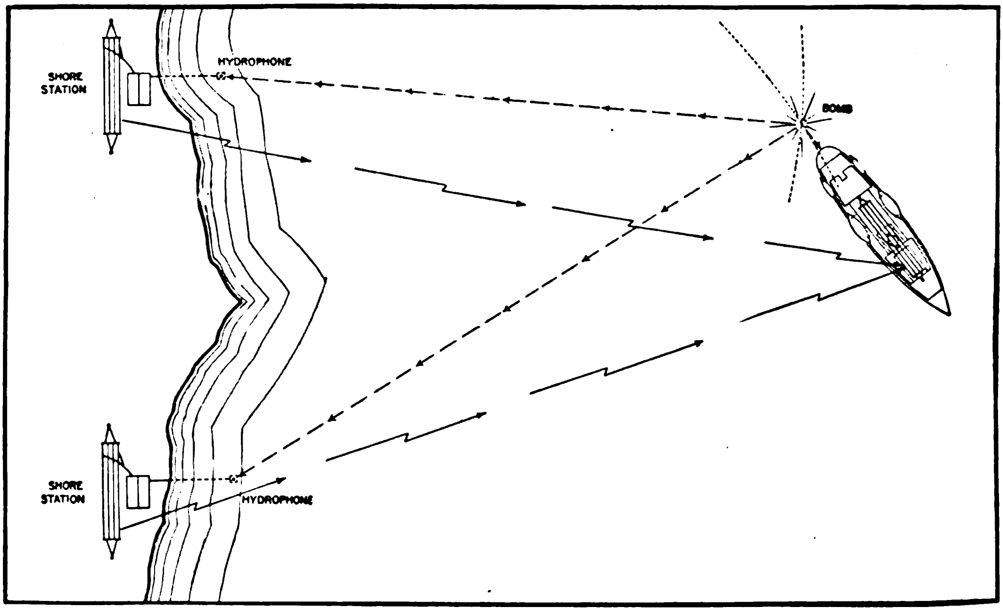
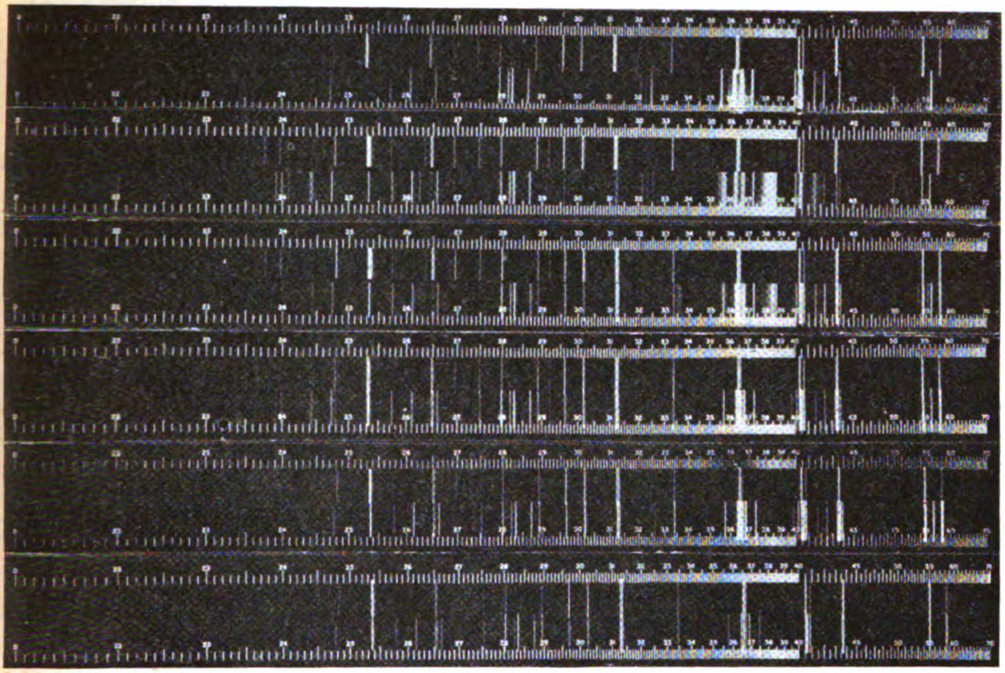
*The method was mentioned by Commander N. H. Heck, of that Survey, in an address before the American Association for the Advancement of Science, at Kansas City, Missouri, on December 29, 1925. Information for the present note has been kindly supplied especially to POPULAR RADIO by Director E. Lester Jones, of the U. S. Coast and Geodetic Survey, Washington, D. C.



U. S. Coast and Geodetic Survey

HOW RADIO AND SOUND WAVES FIX A SHIP'S POSITION

A bomb is dropped from the ship and explodes under water. Sound waves travel through the water, affecting the hydrophones on the sea bottom near shore. This starts the radio transmitter at the shore stations. Their signals are picked up on the ship, thus fixing the time needed for the sound wave to travel from ship to shore. The distance can be calculated from this time.



Courtesy of The Scientific American

THE RECORD OF A SUPPOSED CREATION OF MERCURY

In this series of spectra, photographed by Professor Smits, the lines due to lead become weaker and the lines due to mercury become stronger from the top of the series downward, this corresponding to the length of time that the molten lead had been exposed to electric action in the lamp. Professor Smits believes that this change indicates a transmutation of the atoms of lead into atoms of mercury.

desired, the velocity of the sound wave in the sea water of that particular locality may be determined by exploding bombs and taking the radio records at times of clear weather, when visual checks on shore stations are possible.

Another Alchemist Appears

READERS of POPULAR RADIO will remember the claims made two years ago by Professor Adolf Miethe, of Berlin, that he had succeeded in the age-old quest of the alchemists and had transmuted the element mercury—common quicksilver—into gold. A little later, Professor Hantaro Nagaoka, of Japan, claimed to have accomplished the same feat. Unfortunately, these claims did not stand unchallenged. Some of Professor Miethe's own colleagues, in Berlin, reported against his claim. Professor H. H. Sheldon and Mr. R. S. Estey, of New York University, repeated the experiments, exactly as described by Miethe, but obtained no gold.* Nagaoka's experiments do not seem to have been repeated critically; but they are similarly under suspicion in well-informed scientific circles.

Now appears another scientist who believes that he has accomplished the transmutation of one atom into another. Gold is not involved, the transmutation being of lead atoms into thallium atoms and, ultimately, into mercury atoms. The scientist is Dr. Arthur Smits, well-known and respected Professor of Chemistry in the University of Amsterdam, Holland.† The method is similar to that used by Miethe. Pure lead is put into a quartz tube and heated. Through the vapor of lead thus produced in the tube powerful electric currents are passed, usually in the form of intermittent heavy sparks. The spectrum of the light is photographed. In the beginning, this spectrum shows the lines of lead. As the sparking goes on, the lead lines grow weaker, while lines of thallium and of mercury appear and grow stronger. It is assumed that lead atoms are being converted into thallium or mercury atoms.

Professor Smits' report is straightforward and impressive. However, the scientific world, once bit (however unintentionally) by Professor Miethe, is twice shy. The Amsterdam claim does not seem to have met with very general acceptance. Except for one rather doubtful chemical test, the evidence of the formation of mercury is purely spectrographic, and spectra have a way of performing unexpected tricks.

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*See "The New Alchemy Fails to Make Gold," this Department of POPULAR RADIO for December, 1925, pages 577-578.

†"Transmutation of Elements" by A. Smits. *Nature* (London), vol. 117, pages 13-15 (January 2, 1926), and "The Transmutation of Elements," by A. Smits and A. Karssen. *The Scientific American* (New York), vol. 134, pages 80-81 (February, 1926).

WHAT READERS ASK

CONDUCTED BY HUGH S. KNOWLES

IN *justice to our regular subscribers a nominal fee of $1.00 per question is charged to non-subscribers to cover the cost of this service, and this sum must be inclosed with the letter of inquiry. Subscribers' **inquiries should be limited to one question or one subject.***

The Use of Silver Wire for Bus Wiring

QUESTION: I am rebuilding my receiver and want to make it as efficient as possible. I have used the best parts available throughout and want to spare nothing to make it as fine a set as may be built. I understand that sterling silver is a better conductor than copper. Would you advise me to use it in connecting up the set?

SAMUEL BIRD.

ANSWER: This is a common question; it indicates that some set builders have consulted a table of specific resistances. The conductivity of annealed electrolytic copper is about 95 percent that of *pure* silver. Sterling silver is not pure silver but an alloy that contains considerable copper. Its conductivity therefore, is less than that of pure silver. Aside from this consideration however, and even assuming that pure silver is used, the difference in conductivity does not warrant the additional expense. It would be just as logical to use silver wire in the loop and this would be very expensive. The slight difference in conductivity can be compensated for by using wire a size larger.

The Use of a Wave-trap with Loop Receivers

QUESTION: There is a powerful station about two miles from my house that is very hard to tune out. I am using a standard type eight-tube superheterodyne with a loop. Can a wave-trap be used with a loop antenna? Would it help to eliminate this interference?

HAROLD FIELDING

ANSWER: When the received wave differs sufficiently from the interfering wave, a wave-trap may be used advantageously with any type of antenna. The wave-trap is nothing but a parallel resonant circuit designed to offer a very high impedance to the frequency to which it is tuned. Increasing the resistance of this circuit *decreases* the impedance to this resonant frequency so a good coil and condenser should be used.

As in the case of an outdoor antenna the wave-trap may be used either by connecting it directly in series with the loop or by coupling it to a small coil connected in the loop circuit. In practice this latter arrangement is generally to be recommended since its reaction on the loop circuit may be controlled more easily.

How to Test Large Condensers

QUESTION: I have a few bypass condensers ranging in capacity from .1 to 1 mfd., which I use in making up sets. I have tried testing them with a headset and battery but they all give a pronounced click which I understand should indicate that they are defective. Is there any more accurate method of comparing any two condensers to determine which has the higher resistance, that is, which is the better to use in a set?

WILLIAM CLARK.

ANSWER: The usual phone and battery test is unsatisfactory for condensers of this type. This is due both to the high capacity and to the relatively low resistance of this type of condenser.

High capacity condensers possess a large initial current which will produce a loud click in the phones, while condensers with a low resistance will discharge rapidly enough so that subsequent tests also give a click in the phones.

There is a simple method which may be used to get a relative idea of the resistance of several condensers.

Charge the condensers with fairly large capacities by means of a single dry cell. For small capacities of the order of .0005 mfd. more voltage should be used. (The charge on a condenser is equal to the product of the capacity and the applied voltage.)

The battery should be connected directly across the condenser for a period of from five to thirty seconds or possibly even longer. The reason for this is that the charging time should be the same for all of the condensers compared, and it is somewhat easier to measure a long period of time accurately than a short one.

Wait a few minutes (which should be timed not estimated) and connect the phones across the condenser. Unless the condenser is a poor one there should be a pronounced click, thus showing that the condenser is not completely discharged.

Charge the condensers again and increase the time before testing until there is a barely perceptible click. The condenser that requires the longer time to discharge to this point is the better one, as it has the higher resistance.

It must be remembered that this system is satisfactory only when condensers of the same capacity are to be tested or compared. The relation between the time required to discharge and the resistance is a complicated one and the fact that one condenser takes twice as long to discharge as another does not necessarily indicate that it has half the resistance.

How to Insert a Crystal Detector in the Four-circuit Receiver

QUESTION: I have a Cockaday four-circuit receiver which was built from the description given in the October, 1924 issue of POPULAR RADIO. I have heard that a crystal detector gives better quality than a tube detector, so I should like to experiment with it, even though this set gives very good quality. If I could use it on local stations it might operate satisfactorily and save the heavy "A" battery drain of the UV-200.

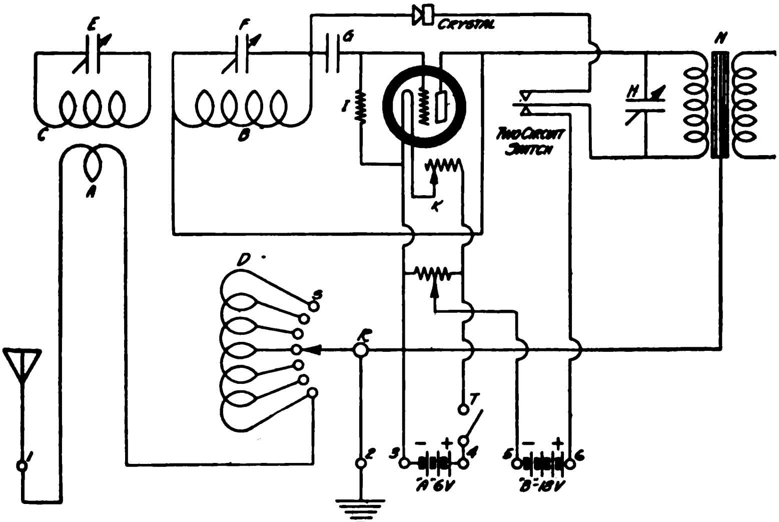
EDWARD CARSON.

ANSWER: This change may be readily made as may be seen from Figure 1.

You will need a single pole double throw switch such as the Yaxley No. 30. Disconnect the "B" plus lead to the audio-frequency transformer from the transformer and connect it to one of the stationary springs of the switch. Connect the transformer binding post just disconnected to the moving spring of the switch. Connect the other lead of the switch to one side of the cyrstal detector and the other side of the detector to the outside lead of coil B as shown.

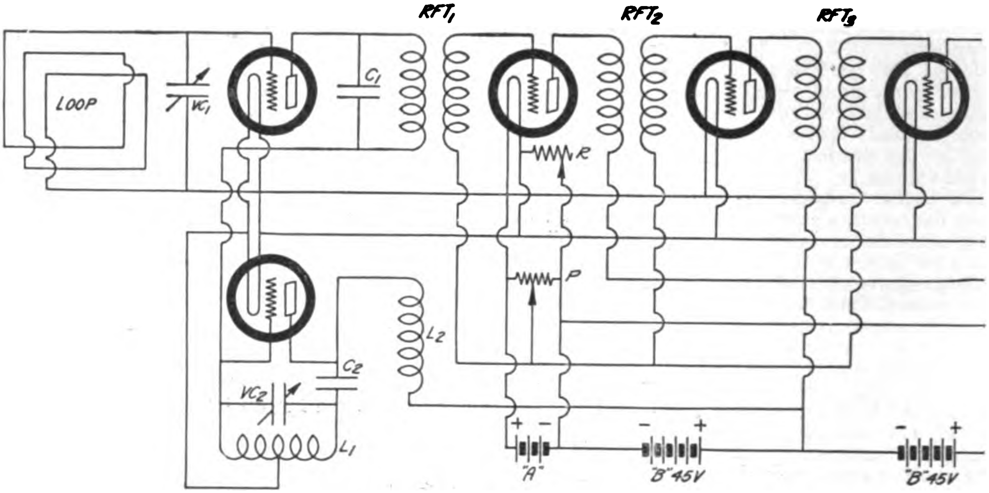
Make the leads to the crystal detector as short and direct as possible and space them as far as possible from the plate leads. If the change from one type of detector to the other is to be made frequently you may find it convenient to put the switch on the panel over the Dublwundr. This necessitates rather long leads and we suggest you mount it on a small brass bracket on the baseboard just back of the first socket.

The letters on the various parts are those used on the original diagram of this receiver.



THE FOUR-CIRCUIT RECEIVER WITH A CRYSTAL DETECTOR

FIGURE 1: *This schematic diagram shows how the change from a vacuum tube to a crystal detector may be made in the Four-circuit receiver. All the lettering in the drawing is identical with that employed in the original diagram of the receiver.*



A SCHEMATIC DIAGRAM OF THE ULTRADYNE

FIGURE 2: *The detailed hook-up of the Ultradyne superheterodyne receiver which is described below. The lettering of the apparatus in the drawing corresponds with that in the printed list of parts.*

How to Build the Ultradyne Superheterodyne

QUESTION: I have heard a great deal lately about the Ultradyne, and as I still have a set of intermediate frequency transformers together with most of the other parts I once used in a nine-tube superheterodyne, I want to build a set using this circuit. Since coils for this receiver cannot be bought locally I would appreciate your giving me the specifications for them as well as the circuit of the set. Will you kindly give me the necessary information as well as a complete diagram that will help me in wiring up?

HENRY BAINBRIDGE.

ANSWER: The circuit of this receiver is given in Figure 2.

You will need the following parts:

RFT1—Intermediate frequency transformer, tuned input;

RFT2, RFT3 and RFT4—Intermediate frequency transformers, untuned;

VC1—Variable condenser, .0005 mfd.;

VC2—Variable condenser, .0005 mfd. vernier;

C1—Condenser, fixed, .0005 mfd.;

C2—Condenser, fixed, .006 mfd.;

C3—Condenser, fixed, .002 mfd.;

C4—Condenser, fixed, .5 mfd.;

GC—Condenser, grid, .00025 mfd.;

GL—Grid-leak, 2 megohm;

P—Potentiometer, 300 to 400 ohm;

R—Rheostat, 2 ohm, 2 to 2.5 ampere capacity;

AFT1 and AFT2—Audio-frequency transformers, first and second stage respectively;

J1 and J2—Double circuit jacks;

L1—Oscillator inductance (57 turns of No. 22 DSC or DCC wire on a 3-inch tube tapped at 28½ turns);

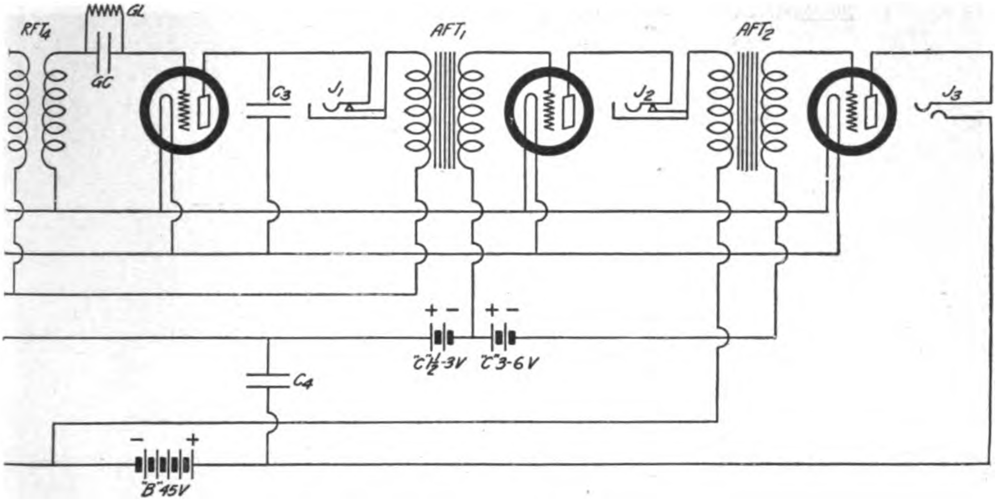
L2—150 to 300 mili-henry choke, small and connected close to plate;

Loop—This should be made by winding 15 or 16 turns of No. 18 wire (preferably stranded or fixture wire for mechanical reasons) on two slotted cross arms. The outside turn should be two feet square with turns spaced about ¼-inch.

The necessary battery voltages are indicated in the diagram.

As the first tube has no plate voltage other than the alternating current voltage supplied by the oscillator, the oscillator must be operated so as to give a larger output than is usually necessary. You may find that the voltage of the first "B" battery block shown in the diagram will have to be as high as 90 volts. As this voltage is also applied to the intermediate frequency amplifier, in this way considerably increasing the "B" battery drain, it may be advisable to connect the oscillator plate to the second block in order to secure the necessary voltage without increasing the amount applied to the intermediate frequency amplifier.

When an oscillator is operated at large outputs there is considerable wave form distortion; that is, considerable energy is present at harmonic frequencies. This is due to the tube characteristic. Consequently you may have trouble with harmonics from the oscillator as well as a few repeat points, particularly on local stations. This trouble may be minimized by using a larger tube of the semi-power type and by employing some negative bias on the grid.



The Use of a Loop or an Antenna Coupler

QUESTION: I have just built one of the McLaughlin single control superheterodynes. I have been unable to obtain one of the loops specified for this receiver. I have been using a Korach loop and the results have been very satisfactory, but I would like to dispense with loops altogether if possible and use my antenna. Can you suggest a means of doing this?

ARTHUR WILLIAMS

ANSWER: Although this can be done rather easily it is not altogether satisfactory and should not be resorted to except when a loop cannot be used. The loop has the advantage of giving a higher signal to static ratio, directional properties, greater selectivity (due partly to the former) and of more nearly giving a straight-line-frequency curve over the portion of the condenser that is used. This last characteristic is important where single control is used, due to the fact that there has to be a constant frequency difference between the oscillator and loop or input circuit.

Where an antenna coupler is used the curve deviates from that obtained with the loop due to the reaction of the antenna circuit on the secondary circuit through the coupling which must necessarily exist between the two. To minimize this effect and to improve selectivity the coupling between the primary and secondary should be loose.

To make an antenna coupler to use with this receiver sixty turns of number 20 DCC or DSC wire should be wound on a 3 or 3¼ inch composition tube. Space an inch and wind eight turns of the same wire for the primary. The four binding posts for the primary and secondary can be mounted directly on the tube. To improve the looks of the unit it can be mounted in a small cabinet and the binding posts mounted on the panel. The two phone tips supplied with the "Imp" jacks should be soldered to two short leads and connected to the secondary of the coupler.

If the antenna is large it may be necessary to connect a .00025 fixed condenser in series with one of the primary leads. Where necessary the selectivity may also be improved by removing turns from the primary.

To place the unit in operation connect the antenna and ground leads to the primary and the two leads from the loop jacks to the secondary binding posts. This should be done while the lid of the set is open so the condensers can be adjusted. Set the midget condenser so that half of the rotor plates are engaged. Tune the receiver while using the headphones until a station is heard. One of the set screws on the coupling connecting the two variable condensers should then be loosened and the oscillator condenser (the rear one) should be rotated slightly until the signal is loudest. The set-screw should then be tightened. The capacity variation which can be gotten through adjusting the midget condenser will compensate for any frequency difference between the oscillator and the loop circuits.

The Menace of the Radio "Press Notice"

> *"Dreaded censorship will certainly come unless the broadcasters wake up to the realization that only clean, wholesome material has any right in God's air. National advertisers will learn that they are causing a feeling of antagonism only when they force their sales talk into the homes of the people."*
>
> —DR. LEE DE FOREST

National Cathedral Foundation

BROADCASTING AN OUT-DOOR CHURCH SERVICE

Not only does the Reverend Microphone appear in the pulpit during divine worship held on on the grounds of the Cathedral of St. Peter and St. Paul in Washington, D. C., but amplifiers are employed (as shown above) for carrying words and music to the assembled multitudes which constitute but a tiny fraction of those who listen in.

The BROADCAST LISTENER

Comments on radio programs, methods and technique —from the point of view of the average fan

By RAYMOND FRANCIS YATES

The Squealing Receiver Is a Social Nuisance

OUR international tests have been the subject of splendid newspaper articles; but the results have been far from satisfying. As a matter of fact, they have been so bad as to bring the whole thing pretty close to a downright fiasco. Each night at the appointed hour the air was found writhing like a mass of worm squeals and howls of every imaginable degree of frequency. To tune into a mess like that in hope of enmeshing a foreign wave was nothing but the shearest folly. Yet thousands upon thousands who, ordinarily could not get beyond the bounds of their state line, strained and struggled to catch one fleeting note of the foreign stations. It was all very sad and very disappointing.

In our rash judgment of the thing, we must not overlook the loads and loads of real sport had by the Radio Boy Scouts. The distance-eaters were as happy as Elks at a carnival. So after all, the trans-Atlantic tests were not the dismal failure they might have been.

In reviewing this trans-Atlantic test business, it is interesting to note that the only thing that prevented complete and glorious success was the presence of the squealing receivers. The carrier waves of all of the British broadcasters were easily heard and it was only the wild shrieks of the unsatisfied tickler coils that made of the whole thing a somewhat grotesque display of the evil spirits of the air.

Is there not some way of making the owner and user of a squealing receiver realize his obligation to his fellow listener? Is there not some way of impressing him with the fact that he is a social nuisance? Then, too, we often wonder if the manufacturers who supplied such contraptions to the public in the early days, do not feel just a little sting of compunction? If they don't, they should.

* * *

How To Listen In

We came to thinking the other day that we had in a measure failed to fulfill our obligation to the hundreds of thousands of our faithful readers who mob the newsstands on the 20th of each month that they may share the wisdom of this philosopher. Here we have been whittling out these clever little items for over a year now and not once have we given the listening public the real inside dope on radio reception. It's a pretty raw deal when you come to think it over; but we hasten to make amends; and now, for the first time, our faithful followers will be given full instructions, which, if followed, will turn every evening at the radio into a period of Alice-In-Wonderland pleasure.

In giving out these secrets of reception, we are naturally assuming that you are that type of body who would much rather listen to a harmonica solo from a local station than to listen to Paderewski at distance of 2,500 miles. Some very dear friends of ours would, strange as it may seem, much rather listen to a harmonica solo at a distance of 2,500 miles than to listen to Paderewski at a distance one mile. That, of course, is one of the great mistakes of listening in and we want to warn you against it right now. The real secret of radio broadcast reception is to keep in your own back yard as far as possible.

And what is the second great secret of perfect reception? Perhaps we shouldn't tell you, but we feel that we owe it to posterity and once you convince yourself that you owe anything to posterity, you ought really to give it up. The second great secret of perfect reception (clearing of the throat) is the simple matter of planning your own program from the material listed at the several nearby stations that supply your nightly entertainment. If you will cultivate the habit of reading the programs with a No. 2 reading glass and if you put your ear right down close to the page of the newspaper, you will be able to detect the best items on each bill. The mere application of a red pencil finishes the job and then you are ready to sit down and enjoy a program that you have in a measure planned yourself. As a practical example of this scheme we are having printed below a copy of a New York program. The features bearing the X were marked at the beginning of the evening. They afforded us not only variety but practically uninterrupted entertainment:

NEW YORK

492—WEAF—610.

6:45-7:45 A. M.—Setting-up exercises.
7:45 A. M.—Morning prayer service.
10:45 A. M.—Home service talk.
11:05 A. M.—Anna Frevola, piano; talk.
11:30 A. M.—Columbia Univerity lecture.
12:00 M.—Market and weather reports.
2:30 P. M.—Government Club meeting; Mrs. George Owens, President.
4:30 P. M.—B. Gorden, tenor; talk.
5:00-6:00 P. M.—Ritz-Carlton Orchestra.
x6:00 P. M.—Waldorf-Astoria dinner music.
7:00 P. M.—Columbia University lecture.
x7:20 P. M.—Iris Torn, piano.
7:30 P. M.—"Lullaby Lady"; songs.
8-00 P. M.—"Pop Concert."
x8:30 P. M.—"Coal Miners' Trio."
x8:45 P. M.—Talk, "Louis Pasteur."
9:00 P. M.—Gypsy Entertainers.
10:00 P. M.—"Norma."
x11:00-12:00 P. M.—Bernie's Orchestra.

455—WJZ—660.

1:00 P. M.—Park Lane Orchestra.
2:00 P. M.—News.
3:30-4:30 P. M.—Helpful talks.
4:32 P. M.—Sherry's Trio.
5:32 P. M.—Market closings and summary.
x7:00 P. M.—Commodore dinner concert.
7:55 P. M.—Talk, John B. Kennedy.
8:00 P. M.—Arion Male Chorus.
x9:00 P. M.—F. F. French dinner: Hadley's Philharmonic Orchestra; Fred F. French, speaker; Mary Garden, soloist.
10:30 P. M.—Waldorf-Astoria Orchestra.

316—WGBS—950.

10:00-11:00 A. M.—Timely talks; music.
1:30 P. M.—Scripture reading.

Kadel & Herbert

THE FIRST RADIOPHONE BOOTH ON A GERMAN EXPRESS TRAIN

Uninterrupted telephone service while you travel along at a rate of sixty miles an hour is the latest convenience which is offered to travellers on the Berlin-Hamburg express in Germany.

1:35 P. M.—Interview, Helen MacKellar.
1:45 P. M.—Piano duets; songs.
3:00 P. M.—Interview, William Harrigan.
3:10 P. M.—Virgil Forrest, piano; Adele Herman, recitations; Women Voter's hour.
6:00 P. M.—Uncle Geebee.
6:30 P. M.—Royal Balalaika Orchestra.
7:00 P. M.—Bankers' Association talk.
7:10 P. M.—Premier Club Orchestra.

341—WMCA—880.

6:00 P. M.—Vail's String Ensemble.
6:30 P. M.—Golden's Orchestra.
x7:30 P. M.—Karnival Kings.
8:00 P. M.—Terminal musicale.
9:00 P. M.—Christian Science lecture.
10:15 P. M.—Messner Quintet.
10:45 P. M.—Barclay musicale.
11:00 P. M.—Manhattan Serenaders.
11:30 P. M.—Frivolity Orchestra.

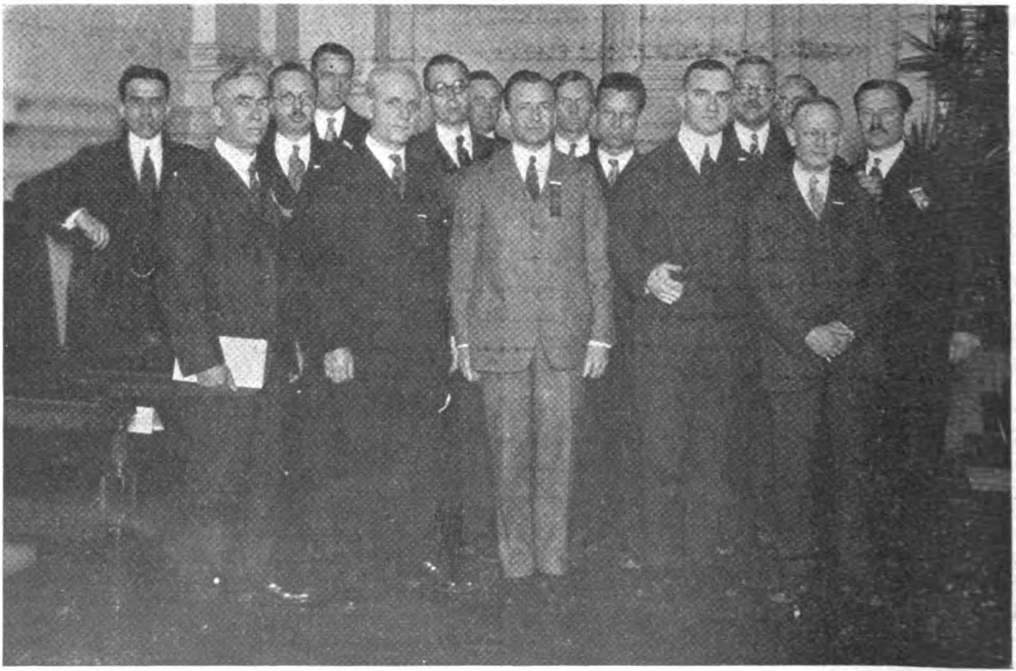
259—WRNY—160.

12:00 M.—Piano; songs.
1:30 P. M.—Studio recital talks.
4:00 P. M.—Studio recital.
7:00 P. M.—Biography sports; commerce.
7:15 P. M.—Songs; entertainers.
x7:45 P. M.—Studio recital; talks.
9:00 P. M.—Piano recital; poems.
9:55 P. M.—Ferrucci's Orchestra.

Temperament in The Studios

THE stories of the temperamental displays of some of our radio artists (and others) are all but incredible. Some of them match the classical example of Mme. Blank who, falling in swoon near the wings at the Metropolitan, required that an attendant be present with a large and effervescent schooner of beer. Madame absolutely and flatly refused to go through this particular opera unless she was permitted to take on liquid refreshment at this particular moment.

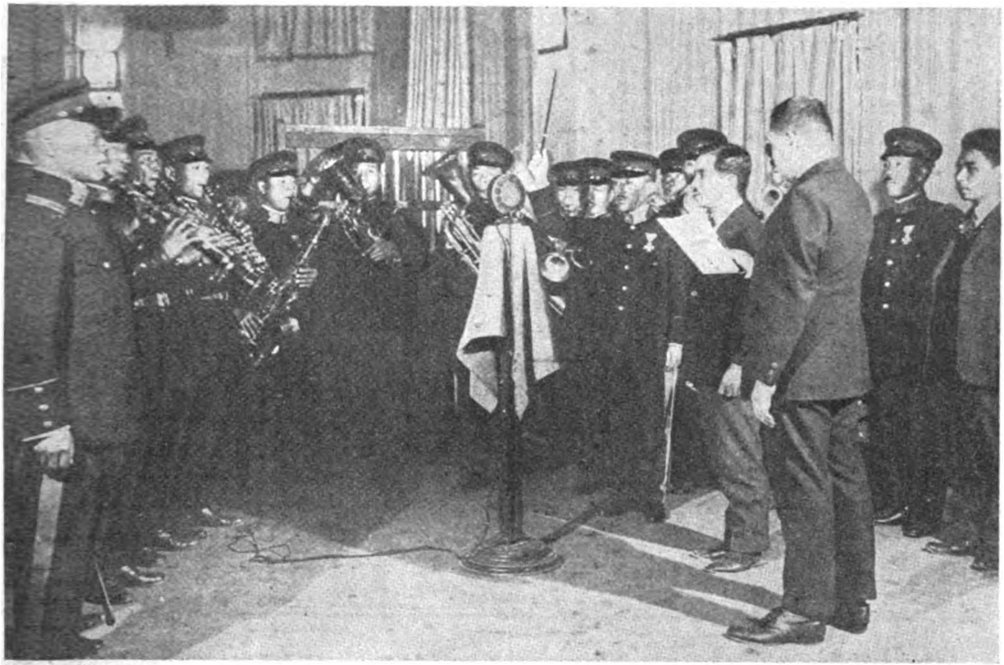
Something that comes pretty close to this high record of subnormal tommyrot occurred some time ago at WEAF. A young lady who had evidently made a very close study of temperament and who felt that she could duplicate the performance of the best of them, decided, at the last moment, that she could not sing unless she was standing squarely upon a piece of sheet metal about half the size of a box car door. Not being much of a metallurgist, she left the choice of the metal to the house, but it had to be about half the size of a box car door. Now, setting out to find a piece of metal about half the size of a box car door, with one minute to work in is no easy job. It happened on this occasion that such a piece of metal was found in the control room. It was not exactly half the size of a box car door so the studio boys really put one over on



Brown Brothers

MEN WHO MAKE RADIO

This picture, which shows perhaps the most distinguished body of radio experts ever assembled in one group, was taken especially for POPULAR RADIO *at the Convention of the Institute of Radio Engineers which was recently held in New York. Reading from left to right, this picture shows Messrs. W. H. Hubley, F. C. Conrad, J. V. L. Hogan, C. W. Horn, D. McNicholl, A. H. Grebe, J. H. Dellinger, J. H. Morecroft, A. N. Goldsmith, G. W. Pickard, R. H. Marriott and E. F. W. Alexanderson.*



Henry Miller

STATION JOAK WELCOMES A PRINCESS WITH A BRASS BAND

The sound of saxophone and clarinet broadcast from the radio station in Tokyo by the band of the Toyama Military Academy recently announced to the waiting people of Japan that a daughter—instead of a son—had been born to their Crown Princess.

the young lady. She might have gone into hysterics had she known that she had sung on a piece of metal that was not exactly half the size of a box car door.

There is another story told about one of Roxy's pianists who insisted that the studio temperature be exactly 70 degrees and that he should be screened off from the rest of the gang while doing his stuff.

Still, that is not so bad when one recalls that even Paderewski carries on tour a woman who is purported to be the only laundress who can starch his cuffs to right degree of hardness.

* * *

$25,000 for One Radio Performance

It was rumored a few weeks ago that the great fiddler Mr. Fritz Kreisler had asked for $25,000 for a single radio performance. That Mr. Kreisler should ask such a large sum for so small an effort is none of this department's business and consequently we shall refrain from expressing our private opinion in the matter.

We often wonder how long it will be before our musical artists will, like the literary aspirants who storm the editors of the *Saturday Evening Post*, be eager and happy to perform for nothing. There are but two important factors in the making of an artist. Genius, or at least what the public recognizes as genius, must be present. Once a musician masters his art he must introduce himself to the world. What greater opportunity for lasting and quick introduction could one ask for compared with the radio? What other medium with one majestic sweep can please the ears of a whole nation in an insignificant fifteen minutes of time? Within a few years' time the concert tour will become a waste of time and effort; radio will find its own geniuses, train them and introduce them. Those haughty *virtuosi* of the present—the younger of them—may some day be on the waiting list of our second-grade studios.

Radio must simply bide its time. The activities of many thousands of ambitious home tinkers to say nothing of work of dozens of hinky-dinky manufacturers of radio receivers has kept radio from being a real serious rival of the concert stage. Eighty percent of the receivers in use today are just about on a par with the early American phonograph with the morning glory horn. Before radio can dominate in music it must do justice to the work of those who entertain. And when it does?—well here's a little prayer for the Fritz Kreislers!

¶ *In the next number will appear the first announcement of the* POPULAR RADIO MEDAL FOR CONSPICUOUS SERVICE.

LISTENING IN

PRACTICAL *pointers from experimenters and broadcast listeners. What helpful hints can* YOU *offer to your fellow fan? Readers are invited to address their letters to the editor of this Department.*

CONDUCTED BY LLOYD JACQUET

How I Marked My Battery Terminals

INSTEAD of the usual color scheme of wiring, I have devised a simple and inexpensive way of marking the battery terminals of a radio set.

First, it is necessary to obtain from a stationery store some metal-edge cardboard tags, either of the round or square variety. The round ones are about one inch in diameter.

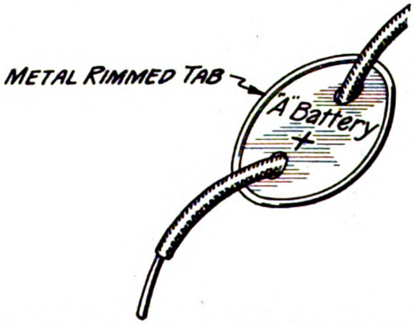
Then print on both sides of the tags, with india ink, the various indications, such as "A" BATT; "B" BATT; GND; ANT; and any others which may be required.

A hole should be punched below these markings, in line with the top hole which is already provided. This lower hole should be so located that it will not obliterate the printing.

As soon as the ink is dry, the tags should be thoroughly shellacked, so as to be moisture and acid-proof. One coat of shellac will be sufficient; and it will dry very quickly.

Then, the wires which have been previously cut to the correct length for the various connections should be passed through the two holes of the tag as shown in Figure 1. The tags should be retained at the ends from which changes in connections will be made. For instance, they should be placed at the very end of the battery wires, so that they may be handy when batteries are changed.

—PETER STEVENS, *Brooklyn, N. Y.*



A MARKER FOR BATTERY WIRES

FIGURE 1: *How the small metal-rimmed tab is slipped over your battery terminals. This will help to prevent costly errors in wiring.*

* * *

How a Community Radio Service Is Maintained

IN this community there is only one receiving set. This is in charge of a competent radio operator, who is somewhat of an artist as well. He has installed a powerful radio receiving set of his own construction, in which some 20 vacuum tubes are utilized.

By means of a master wire, which is a No. 9 galvanized iron wire running over fences, trees and buildings, and under a sewer, the railroad right of way and bridges, to every section of our hilly little city, this receiver serves about 200 homes.

None of the "subscribers" to this service have any receiving set, batteries, or horns. The only attachment is a unit which may be placed on the phonograph tone arm, and which connects to the line and to the ground. This is the only equipment necessary at the home of any listener in.

We have no tuning to do; and we get our programs entirely without interruption. The best programs and the finest stations from coast to coast are tuned in by our operator, who knows what to listen for, and gives us the best.

The service is continuous from 8 A.M. till late in the evening. When special events are broadcast, such as baseball games, operas, presidential speeches or Sunday services, all we need to do is to listen, for it will have been tuned in for us on the instant.

There is a slight initial installation charge and a monthly fee which is also small in comparison with the service given. The city council has passed the idea. Although we welcome newcomers on the air, there are very few of them, because this service is satisfactory. We have no squeals or noises; and the radiation nuisance is automatically taken care of. With all the mess and care of radio taken out, we find that it is an ideal way to listen in.

We believe that this community is the first one in the country to work out this idea, which is beyond an experiment at the present stage.

—**Jesse Shimp**, *Mannington, W. Va.*

* * *

How I Am Able to Use Either Dry-Cell or Storage Batteries with My Neutrodyne Receiver

With the idea of making my neutrodyne receiver a semi-portable proposition during the summer months, I installed dry-cell tubes in it in place of the standard tubes which operate on storage batteries.

This did not work well, mainly because the internal capacity of the small dry-cell tubes is less than that of the standard type of tube. As the tubes make up a part of the neutralizing circuit, this circuit is unbalanced as soon as the tube capacity becomes smaller or greater.

To take care of this change in capacity I converted my neutralizing condensers, which are of the usual construction, into semi-variable ones, which are so conceived that it is easy to shift from dry-cell to storage battery operation and vice versa in an instant.

To accomplish this the proper point for the setting of the movable rod (shown in Figure 2) which slides into the glass tube is first found for both types of tubes, and marked. Then, the end of the rod is bent upward and the point nicked so that it may be automatically set by a spring when it is withdrawn. In this way the conversion of the neutralizing condenser for dry-cell or storage battery tubes is simply done.

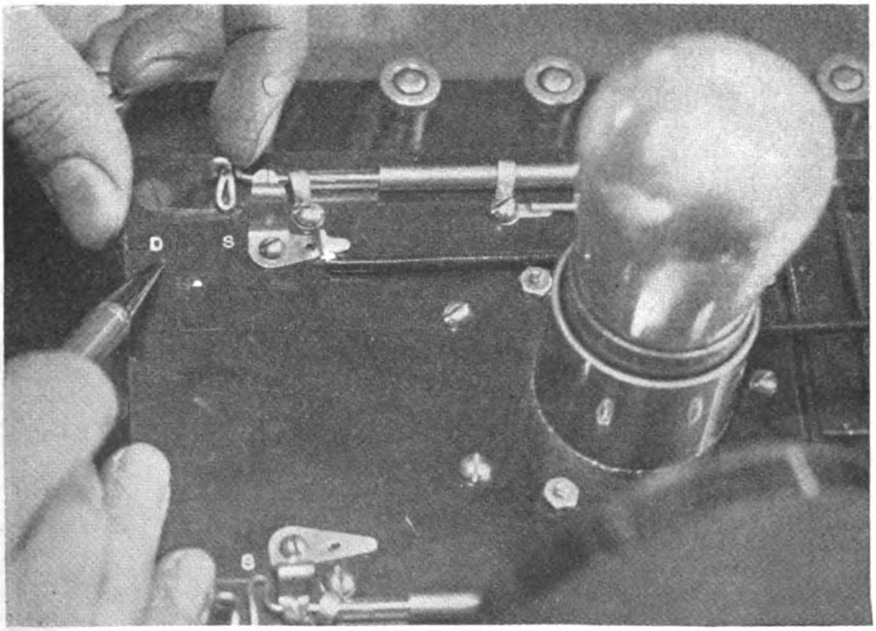
As more capacity will have to be added to the circuit when storage tubes are used and as less will be needed for the dry-cell type, the rod is correspondingly pressed all the way in, or driven all the way out to the stopping point.

—**Mortimer Treadwell**, *New York*

* * *

How to Check Your Wavelength

Amateurs who would like to check-up the wavelengths of their sets with which they use more than one antenna or in which they hook in or out several coils or condensers will find an innovation of the Bureau of Standards useful to them. The Bureau's announcement (given below) tells how the wavelength check-up is conducted:



F. A. D. Andrea

HOW ONE FAN MARKED HIS NEUTRALIZING CONDENSERS

Figure 2: *This picture shows the movable rod about to be slipped from the proper position for the storage battery tubes, as denoted by the letter S, over to the correct position for the neutralization of dry-cell tubes, as denoted by the letter D.*

"The Bureau of Standards transmits, twice a month, radio signals of definitely announced frequencies, for use by the public in standardizing wavemeters and transmitting and receiving apparatus. The signals are transmitted from the Bureau's station, WWV, at Washington, D. C., and from station 6XBM, Stanford University, California.

"The transmissions are by unmodulated continuous-wave telegraphy. A complete frequency transmission includes a 'general call,' a 'standard frequency signal,' and 'announcements.' The 'general call' is given at the beginning of the 8-minute period and continues for about 2 minutes. This includes a statement of the frequency. The 'standard frequency signal' is a series of very long dashes with the call letters (WWV or 6XBM) intervening. This signal continues for about 4 minutes. The 'announcements' are on the same frequency as the 'standard frequency signal' just transmitted and contain a statement of the measured frequency. An announcement of the next frequency to be transmitted is then given. There is then a 4-minute interval while the transmitting set is adjusted for the next frequency."

The schedule of standard frequency signals may be obtained from both the Bureau of Standards and Stanford Univeristy.

—James Bush, *Washington, D. C.*

* * *

How the Position of Loudspeakers Affects Reception

By properly locating my loudspeaker I succeeded in greatly improving the quality of reception.

At first, I used a horn type of speaker. By locating this instrument in such a way that the opening of the horn was at about the same height as the ear of the auditor, noticeably better results were had than if it is was placed on a high piece of furniture above his head.

Similarly, I have obtained better results by placing my horn in one of the corners of the room, rather than with its back to one of the walls. If the wall opposite the horn was covered with drapery, the tones were softened. If the horn was not properly placed in a big room, echoes which marred the quality resulted.

The cone type of loud speaker may be used anywhere, and in any position. I found it best, however, to place it in front of a wall covered with drapery.

—Lawrence Neals, *Dayton, O.*

* * *

How a Swedish Amateur Built His Radio Receiver

It will probably interest my fellow readers of this department to see how a Swedish amateur built his set. In the picture (Figure 3) is shown a back view of a receiver which I constructed from one of the "How to Build" articles published in Popular Radio for April, 1924.

With a few exceptions, the parts of the receiver, such as the condensers, rheostats, sockets, binding posts, coils and so forth are all homemade. The tubes were purchased, of course. The radio-frequency stage is equipped with a UV-201-a, while the detector and audio stages have Phillips a-310 tubes.

With this receiver I have heard most of the broadcasting stations in Europe; and it has been a welcome successor to my former, a whistling, single-circuit receiver. Unfortunately, this latter is the most popular type of set here at the present time.

Needless to say, we watch with interest the progress of American amateurs, who are well equipped with parts and apparatus, and who have the best magazines published.

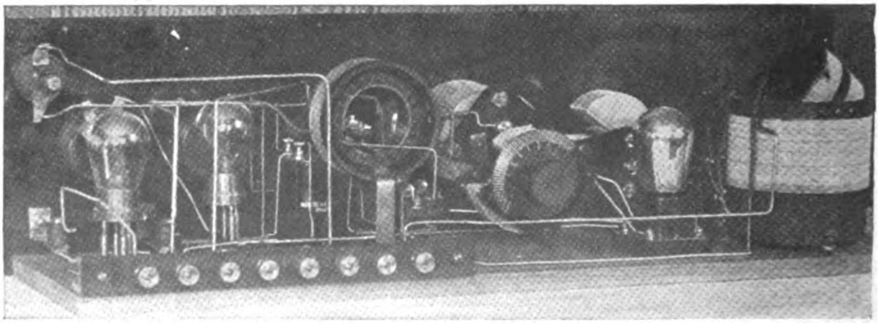
—K. A. Svensson, *Vigge, Juntland, Sweden*

* * *

What the L-C 26 Receiver Brought In

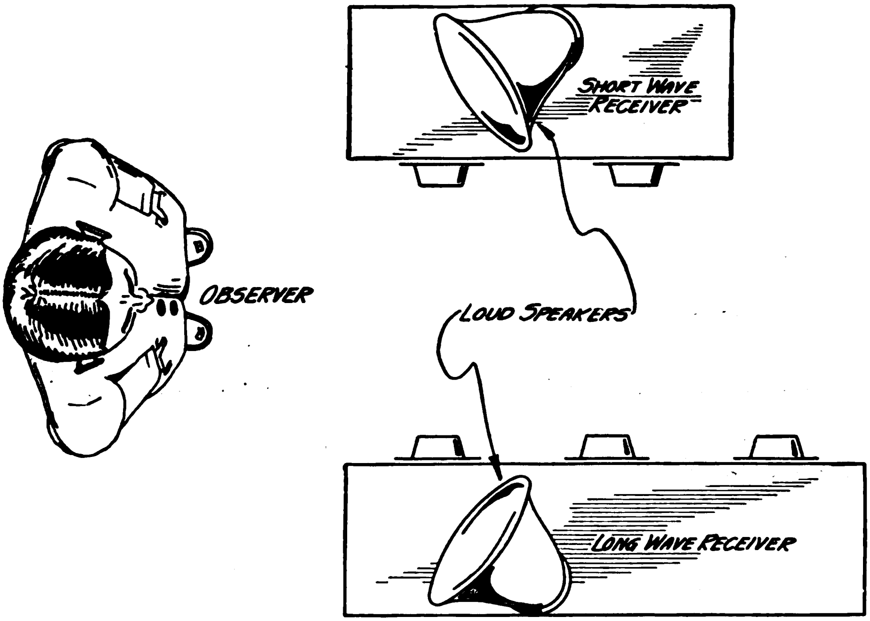
The reference in the February issue of Popular Radio to the results which were obtained in different sections of the country with the LC-26 Receiver has prompted me to express to you my great satisfaction in the results which I have obtained with this receiver which I built shortly after the publication of the article.

I have been able to receive with loudspeaker volume nearly all of the principal broadcasting stations in the country, including Pacific Coast



A "POPULAR RADIO" RECEIVER BUILT BY A SWEDISH AMATEUR

Figure 3: *Although this radio experimenter had to build most of the parts for this receiver he got the results he wanted. It is the Craig receiver, the details of which were published in the April, 1924, issue of this magazine.*



THE DOUBLE RECEPTION SYSTEM

FIGURE 4: *This stereoscopic receiving system is designed to operate on short-wave and long-wave signals transmitted by the same station with one receiver especially designed to bring in the high notes and the other one designed to bring in the low notes.*

stations. On one occasion, the experience was so unusual that I believe it is worthy of special mention.

From two to three o'clock, daytime, I tuned in with loudspeaker volume thirteen stations, including Davenport and Omaha, and WJZ, New York. This represents real daylight DX for this receiver for this location.

It has been possible for me to tune in the setting up exercises of WLW in the morning. I held Mexico City during an entire evening with loudspeaker volume. It is a pleasure to operate such a set as the LC-26.

—LEROY H. HABENICHT, *Kershaw, S. C.*

* * *

Have You Ever Tried Stereoscopic Reception?

EVERYONE is familiar with the stereoscope, the device by means of which two similar photographs which have been taken simultaneously, but at a different angle, are made to give one the illusion of relief.

In a similar way a broadcast listener may obtain the idea of tones and overtones as though he were sitting in the auditorium itself by means of what I call stereoscopic reception.

Two loudspeakers are connected to two receiving sets which are tuned to a station which is broadcasting one program, on two different wavelengths. There are several stations which are doing this today, such as KDKA and WGY.

One of the receivers is tuned to the long wave while the other set is receiving the short wave which is simultaneously broadcast. By placing the two loudspeakers in one room, about five to six feet apart, and with both cones or horns facing a spot which is equally distant from each an unusual result will be experienced by the listener, who should be at the spot where the lines from the loudspeakers converge, as shown in Figure 4.

By designing the radio sets so that one of them will bring in the low wave lengths with good low notes, and so that the long wave set will specially amplify the high notes, the entire scale will be covered and practically perfect reproduction will result.

—JACK HALY, *Brooklyn, N. Y.*

* * *

It's Easy to Simplify Your Panel Arrangement

As the general trend is towards simplification, I decided to simplify the front panel of my radio receiver by eliminating some of the controls.

The first ones to go were the rheostats. I did not do away with rheostats altogether; but by removing them from the panel and placing them behind the panel on a conveniently located strip, I removed three controls from the front of the panel.

The rheostats, when they are once adjusted, need not be regulated for a long period of time; and if a trickle charger is used, it will hardly be necessary to change the settings even over a period of months.

With the straight-line frequency converters which are equipped with fine verniers, I retained my old variable condensers, but did away with the smaller vernier control knobs.

—PAUL MARTON, *Cleveland, O.*

WHAT'S NEW IN RADIO APPARATUS

This department is conducted by Popular Radio Laboratory *for the purpose of keeping the radio experimenter and the broadcast listener informed concerning the newest inventions and the approved developments in radio equipment. Only such apparatus as has been tested and endorsed by the Laboratory is noted in these columns.*

Apparatus Approved by Popular Radio

This list of apparatus approved by the Popular Radio Laboratory will be continued as a part of the WHAT'S NEW IN RADIO APPARATUS department until all instruments, parts and complete sets have been included. The listing is alphabetical by manufacturer's name and the installment in this issue includes only the letters F through G.

AERIALS

Antenella; Chas. Freshman Co., Inc.

AUDIO-FREQUENCY TRANSFORMERS

Federal transformer; Federal Telephone Mfg. Corp.
Supertron A. F. transformer; Ford Mica Co.
Audio-frequency transformer; General Radio Co.
Audio-frequency transformer; Gilfillan Bros., Inc.

BATTERIES

Ray-O-Vac "B" and "C" batteries; French Battery & Carbon Co.

BATTERY CHARGERS AND RECTIFIERS

Balkite trickle charger; Fansteel Products Co., Inc.
Fore battery charger; Fore Electrical Mfg. Co.
Unitron battery charger; Forest Electric Co.
"FF" battery charger; France Mfg. Co.
France super-charger; France Mfg. Co.
Tungar battery charger; General Electric Co.
"Unipower"; Gould Storage Battery Co.

BATTERY ELIMINATORS

Fansteel Balkite "B" plate current supply; Fansteel Products Co., Inc.
Freshman Master "B" eliminator; Chas. Freshman Co., Inc.

BINDING POSTS

G-K spring binding post; Ganio-Kramer Co., Inc.
Binding posts; General Radio Co.
Jack binding post; Globe Phone Mfg. Co.

CRYSTAL DETECTORS

Variotector; Foote Radio Co.
Giant crystal; Foote Radio Co.
Adjustable crystal detector; Chas. Freshman Co., Inc.
Fixed reflex detector; Grewol Mfg. Co.
Grewol 2 in 1 crystal; Grewol Mfg. Co.

DIALS

Dial; Chas. Freshman Co., Inc.
Knobs and dials; General Radio Co.
Knobs and dials; Gilfillan Bros., Inc.
Gee-Haw vernier dial; Otto R. Gischow Co., Inc.
Fynur vernier control; August Goertz & Co., Inc.

FIXED CONDENSERS

Micadenser; Ben Franklin Radio Mfg. Co.
Fixed condenser; Chas. Freshman Co., Inc.

GRID-LEAKS AND RESISTANCES

Fixed grid-leak; Chas. Freshman Co., Inc.

HEADPHONES

Frost Fones; Herbert H. Frost, Inc.
Globe phones; Globe Phone Mfg. Co.
"N & K" phones; Goldschmidt Corp.

INSULATORS

Porcelain; stand-off, and glass insulators; M. M. Fleron & Son, Inc.
Insulators; General Radio Co.

JACKS

Federal jacks; Federal Telephone Mfg. Corp.
Frost Pan-Tab jack; Herbert H. Frost, Inc.

KITS

Freshman tuned-radio-frequency kit; Chas. Freshman Co., Inc.

LIGHTNING ARRESTORS

Refillable lightning arrestor; M. M. Fleron & Son, Inc.
Gray lightning arrestor; Gray Products, Inc.

LOOPS

Hand-D-Tena; Frost Radio Specialty Co.
Effarsee portable antennae; Fishwick Radio Co.

LOUDSPEAKERS

Farrand-Godley speaker; Farrand Mfg. Co., Inc.
Fibertone horn and base; Fiber Products Co.
"Town crier" loudspeaker; Gale Radio Laboratories
"N & K" imported loudspeaker; Th. Goldschmidt Corp.
"G. G. H. Majestic" loudspeaker; Grigsby-Grunow-Hinds Co.

MISCELLANEOUS ACCESSORIES

Reddy Hot soldering kit; E. D. Fahlberg Mfg. Co.
Fahnestock antenna connector; Fahnestock Electric Co.
Fahnestock ground clamp; Fahnestock Electric Co.
Fahnestock clips; Fahnestock Electric Co.
Soldercake; C. de P. Field Co.
"Perfecto" soldering fluid; John Firth
Fleming jiffy connector unit; Fleming Mfg. Co.
Vernier adjuster; M. M. Fleron & Son, Inc.
Lead-in bushing; M. M. Fleron & Son, Inc.
Loudspeaker extension unit; Four Way Co.
"Fits-all" head cushion; Francisco Mfg. Co.
Radio aerial mast fittings; Freidag Mfg. Co.
Frost radio jac-box; Herbert H. Frost, Inc.
Frost ground clamp; Herbert H. Frost, Inc.
Frost radio protector; Herbert H. Frost, Inc.
Frost extension cord; Herbert H. Frost, Inc.
Kant-Blo signals; Ganio-Kramer Co., Inc.
Filter; General Radio Co.
Giant ground clamp; Giant Clamp Works.
Battery mats, spaghetti tubing, hard rubber tube, radiophone ear cushion; B. F. Goodrich Rubber Co.

PANELS

Fibroc bakelite panel; Fibroc Insulation Co.
Electrosote radio panel; M. M. Fleron & Son, Inc.
Formica panels; Formica Insulation Co.
Hard rubber radio panel; B. F. Goodrich Rubber Co.

PHONE PLUGS

Federal plug; Federal Telephone Mfg. Corp.
"4-Way" switch plug; Four Way Co.
Frost plug and jack; Herbert H. Frost, Inc.
Frost plugs; Herbert H. Frost, Inc.
Comsco automatic "Bull Dog Grip" plug; General Instrument Corp.

PHONOGRAPH ATTACHMENTS

"N & K" phonograph unit; Th. Goldschmidt Corp.

POTENTIOMETERS

Potentiometer; Gilfillan Bros., Inc.

POWER AMPLIFIERS

Power amplifier; General Radio Co.

RADIO-FREQUENCY TRANSFORMERS

Farrand-Godley transformer No. 301; Farrand Mfg. Co., Inc.
Federal transformer; Federal Telephone Mfg. Corp.
"Gen-Win" tuned air-core transformer; General Radio Winding Co.

RECEIVING SETS

Faraway radio sets; Faraway Radio Co.
Federal receivers; Federal Telephone Mfg. Corp.
Ferguson "Six" and "Eight" receivers; J. B. Ferguson, Inc.
Flash vest pocket radio; Flash Radio Corp.
Freed-Eiseman neutrodyne receiver; Freed-Eiseman Radio Corp.
Freed-Eiseman NR-6 receiver; Freed-Eiseman Radio Corp.
Masterpiece receivers; Chas. Freshman Co., Inc.
"Garod" broadcast receivers; Garod Corp.
"Voceleste" portable receiver; General American Radio Corp.
Gilfillan neutrodyne; Gilfillan Bros., Inc.
Gold Medal receiver; Gold Medal Radio Corp.
Pliodyne receivers; Golden-Leutz, Inc.
Grebe broadcast receiver; A. H. Grebe & Co., Inc.
Nightingale Six Speaker set; Guthrie Co.
American Crest receiver; Guthrie Co.
Hansel receivers; Guthrie Co.

RHEOSTATS

Rheostat; Framingham Co.
Frost tube control unit; Herbert H. Frost, Inc.
Frost bakelite rheostat; Herbert H. Frost, Inc.
Frost metal frame rheostat; Herbert H. Frost, Inc.
Rheostat; General Instrument Corp.
Rheostats; General Radio Co.
Rheostat; Gilfillan Bros., Inc.

SOCKETS AND ADAPTERS

Federal socket; Federal Telephone Mfg. Corp.
Porcelain socket; M. M. Fleron & Son, Inc.
Phonograph adapter; M. M. Fleron & Son, Inc.
Frost sockets; Herbert H. Frost, Inc.
Frost adapter; Herbert H. Frost, Inc.
General Radio sockets; General Radio Co.
Sockets and adapters; Gilfillan Bros., Inc.
V. T. socket; B. F. Goodrich Rubber Co.

SWITCHES

Anti-capacity switch; Federal Telephone Mfg. Corp.
Frost radio battery switch; Herbert H. Frost, Inc.
Frost bakelite toggle switch; Herbert H. Frost, Inc.
Panel switches; General Radio Co.

A VARIABLE RATIO VERNIER DIAL

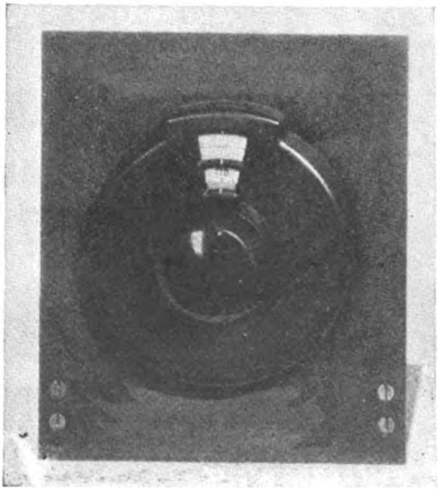
Name of instrument: SLF tuning dial.

Description: This dial is designed to operate with an ordinary straight-line-capacity condenser for obtaining straight-line-frequency tuning. It accomplishes the same results as using a straight-line-frequency condenser with an ordinary dial. The condenser shaft is fastened to a plate in which is cut a straight slot which engages a ball bearing operating in a spiral cam slot mounted directly on the moving part of the dial. Throughout the first lower settings of the dial, the condenser revolves much slower than the dial itself, but this ratio of movement of the condenser and the dial increases until at the upper settings of the dial the condenser is moving at an increased rate. The rate of change of capacity with dial setting is of course correct for producing straight-line-frequency tuning when used in connection with the proper coil and condenser.

Usage: In any radio-frequency circuit for controlling the tuning apparatus.

Outstanding features: Converts old sets to the new style of tuning. Equipped with space for writing in station call letters directly on the moving dial.

(*Further details furnished on request*)



Switch; Gilfillan Bros., Inc.
Double-pole, double-throw switch; Globe Phone Mfg. Co.
Single-pole, double-throw switch; Globe Phone Mfg. Co.

TESTING INSTRUMENTS

No. 1 hydrometer set; Francis L. Freas Glass Works
Clearview hydrometer set; Francis L. Freas Glass Works
Radio "B" hydrometer set; Francis L. Freas Glass Works.
Battery tester; Francis L. Freas Glass Works.
Laboratory instruments; General Radio Co.
Ammeter; General Radio Co.
Wavemeter; General Radio Co.

TOOLS AND EQUIPMENT

Franklin coil winder; Franklin Coil Winder
Windham wire former; Goyer Co.

TUBES

Magic-Tron Vacuum tube, type 201-a; F. & C. Corp.
Gem 201-a tube; Gem Tube Co.
Gold Seal tubes; Gold Seal Products Co.

TUNING INDUCTANCE UNITS

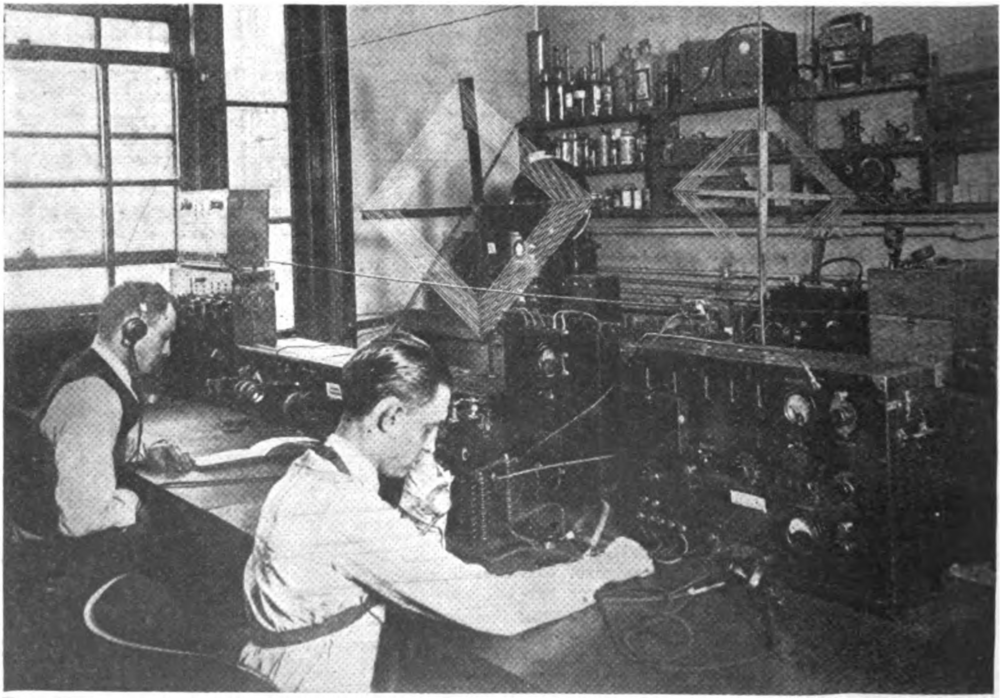
Variocoupler; Federal Telephone Mfg. Corp.
Ferbend wave-trap; Ferbend Electric Co.
Fischer coupler; G. H. Fischer & Co.
Variometer; G. H. Fischer & Co.
Coast coil; Foote Radio Co.
Heliotor (toroid coil); Geo. A. Freeburg Co.
Masterpiece coil and condenser; Chas. Freshman Co., Inc.
Variometer; General Radio Co.
Variocoupler; General Radio Co.
Low-loss coils; General Radio Co.
"Gen-Win" low-loss tuner; General Radio Winding Co
"Gen-Win" variometer, variocoupler, reflex coil, Master tuning coil, neutorflex coil; General Radio Winding Co.
"Gen-Win" Cockaday unit; General Radio Winding Co.
Variocoupler; Gilfillan Bros., Inc.
Variometer; Gilfillan Bros., Inc.
Globe low-loss tuner; Globe Radio Equip. Co.
Short-Wave tuner; L. W. Goodman
Variometer forms; B. F. Goodrich Rubber Co.
Grebe clarifier; A. H. Grebe & Co., Inc.

VARIABLE CONDENSERS

Variable condenser; Federal Telephone Mfg. Corp.
Craftsman condenser; Fett & Kimmel.
Variable condenser; Chas. Freshman Co., Inc.
Furnell taper coil condenser; Furnell Mfg. Corp.
"Continental" vernier condenser; Gardiner & Hepburn Co., Inc.
"Unitrol" condenser; Gardiner & Hepburn, Inc.
Separator; Gardiner & Hepburn, Inc.
Garod straightline condenser; Garod Corp.
Allen dial vernier; General Eng. & Model Works.
Concentric S. L. F. condenser; General Instrument Corp.
Multiple condenser; General Instrument Corp.
Tandem condenser; General Radio Co.
General Radio straight-line wavelength condenser; General Radio Co.
Air condenser; Gilfillan Bros., Inc.
Vari-grid; Grewol Mfg. Co.
"Nol-loss" variable condenser; B. Grosser Sons Co., Inc.

WIRE

Rubber covered wire, metal shielded; Herbert H. Frost, Inc.



Henry Miller

RADIO SETS FOR COMMUNICATING UNDERGROUND

While miners pursue their work far beneath the earth's surface, radio apparatus such as this is employed to maintain constant communication with the outside world. The apparatus shown here is employed by the Bureau of Mines in tests which aim to perfect this type of communication.

IN THE EXPERIMENTER'S LABORATORY

Conducted by Laurence M. Cockaday

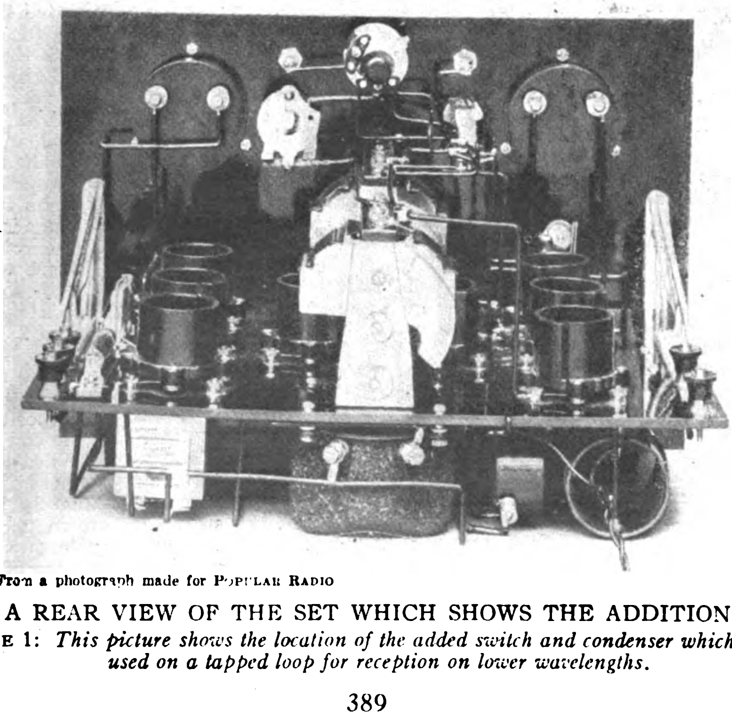
"More About the McLaughlin Superheterodyne"

One of the questions most frequently asked in regard to the single-control superheterodyne receiver (described in the October issue of **Popular Radio**) is "Do I absolutely have to use the D.T.W. loop with my single-control?"

Yes, it is absolutely necessary to use the D.T.W. loop with this set. This is so because of the balance which should exist between the oscillator and the first detector circuit (frequency-changer).

The inductance of this particular loop, with its distributed capacity, has a fundamental equal to the oscillator coil with approximately half the capacity of the midget condenser. If another make of loop is substituted, this balance is destroyed, thus forfeiting all possibility of the complete synchronization of the tunable circuits. Differently designed loops possess distinct and varying electrical characteristics.

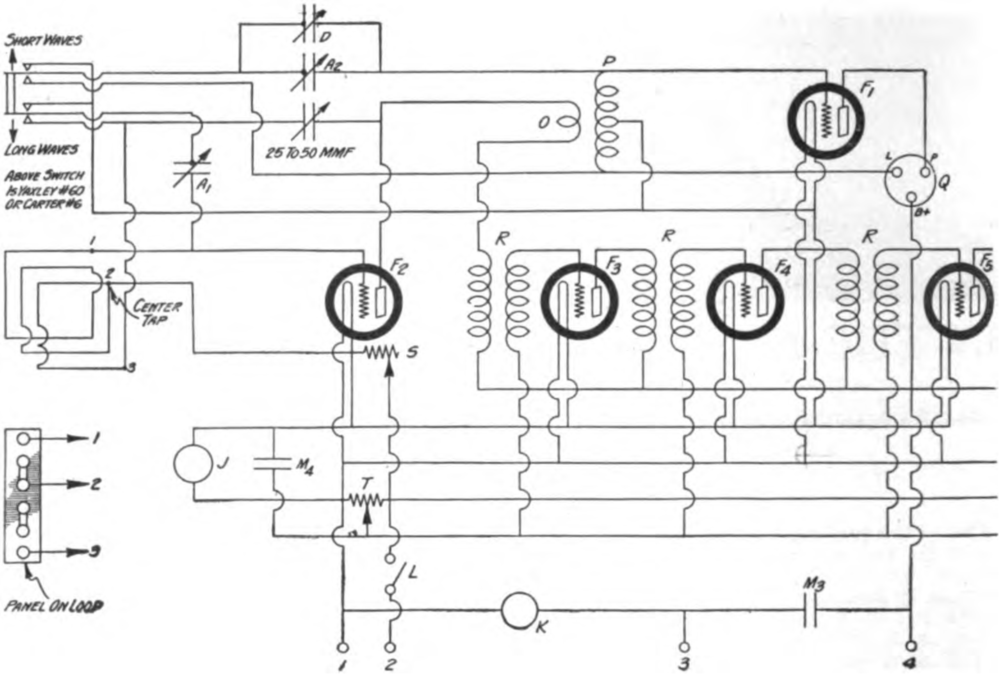
The Litzendraht (high-frequency cable) has not proven satisfactory in coil design due to the breaking of strands generally caused by undue haste in production. In the face of this, it is noteworthy that when two loops of the same physical dimensions and electrical characteristics, one the D.T.W. loop (using Litzendraht), the



From a photograph made for Popular Radio

A REAR VIEW OF THE SET WHICH SHOWS THE ADDITIONS

Figure 1: *This picture shows the location of the added switch and condenser which must be used on a tapped loop for reception on lower wavelengths.*



other wound with ordinary loop wire, were successively connected to the identical receiver, the D.T.W. loop produced a considerable increase in signal strength over that of the other loop. Laboratory tests are now being conducted to ascertain what percentage of increase the D.T.W. loop accomplishes over that of the loop using the so-called loop wire. This increase proves itself on reception from both local and distant stations.

Many persons deplore the fact that the set will not tune below 250 meters and write to ask whether or not they have made some mistake in construction or whether the design was intentional in this respect. The guiding motive in the design of this receiver was to perfect an instrument which would receive good broadcasting and accomplish realistic reproduction.

To every individual who listens to a class A station one will find a hundred or more who will choose a class B station when they want an honest-to-goodness program. Be it understood, however, that poor reception below 250 meters is not always due to poor transmitting equipment or to unwisely selected programs, but is generally caused by the congestion which exists in this frequency range and by harmonics of stations operating at lower frequencies whose fundamentals are twice or three times that of the stations whose programs are being received.

A loop receiver can be made to function more efficiently over the class B range than over the two ranges together. In this set the loop used has considerably more inductance than common practice permits. A loop that has higher inductance exposes more area to incoming oscillations, which results in more current being collected by the loop, *i.e.*, greater signal strength.

But in cutting down the turns of the loop or inductance, we will reach those lower wavelength stations which we do not want after we have them. In other words, we sacrifice reception on the lower wavelengths for better reception on the higher ones.

Inasmuch as we have intimated that it would be far better not to listen to broadcasting on the lower wavelengths, we feel sure that there will be many fans who will go exploring. To them the following information is offered:

If the tuning condenser across the loop is connected across but half the loop the tuning range on this circuit would be changed. So in the oscillating circuit; if we connect the tuning condenser across half the coil, its tuning range will also be changed. This change is of the same value as the change in the loop circuit. If such is the case, then in order to get to our lower wavelength stations, we need only to change the positions of our condensers electrically.

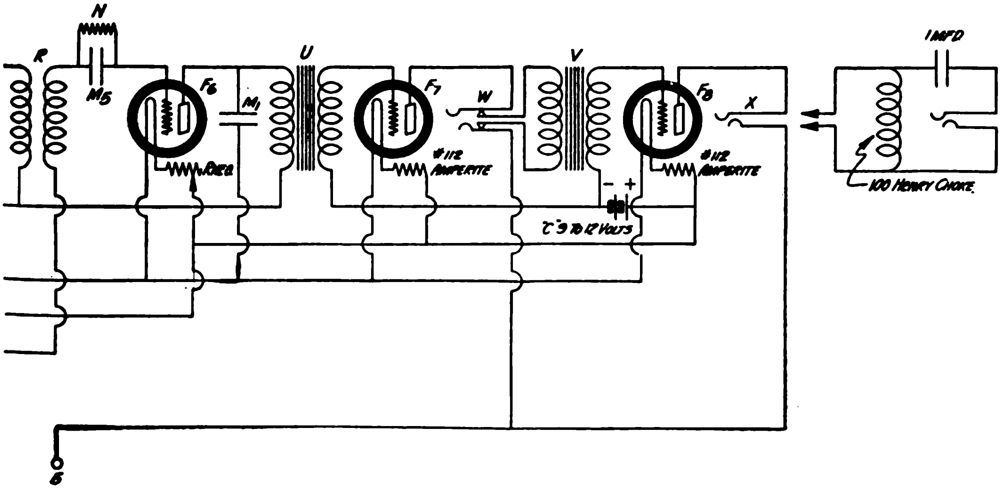
This is shown in Figures 1 and 2.

A Yaxley No. 60 or a Carter No. 6 panel-switch is necessary. This may be mounted on the panel as is shown in Figure 3. The function of this switch is to change the position of both condensers across either half the coil and loop or across all the coil and loop. When the switch is turned one way the tuning range of the set will be from 175 meters to approximately 500 meters, and when the switch is thrown in the reverse position it will be from 250 meters up to approximately 700 meters. The insertion of this switch in the circuit will by no means impair the general efficiency of the set.

An easy way to obtain higher amplification and better selectivity on distant stations is to add regeneration to the first detector. This may be

THE WIRING DIAGRAM FOR THE COMPLETE McLAUGHLIN SINGLE-CONTROL SUPERHETERODYNE

FIGURE 2: *The changes in the electrical circuit which must be made in adding the tapped loop and the vernier condensers and the way in which the "C" battery and the filter unit for the loudspeaker should be included are shown here.*



effected by connecting one side of a small midget condenser to the plate terminal of the detector tube, and the other side to the lower terminal of the loop.

Figure 2 shows just how this may be accomplished. Condenser M2 must be disconnected from the circuit in order to obtain the most satisfactory results. When the best position for this condenser has been found, it should be undisturbed by further adjustments. Changing this will slightly vary the balance between the oscillator and loop circuits.

Many have inquired as to the proper way of coupling the first detector to the oscillator. One complete turn, in either direction, is looped around the oscillator coil, near the end of the windings, with a piece of flexible wire of any convenient size between 20 and 16.

Distortion may be noticed on especially loud stations because the 201-a type tubes, in the audio stages, are not large enough to properly amplify the energy received. In order to remedy this condition the UX-112 Radiotron may be used in the last audio stage and the No. 112 Amperite inserted in the negative filament lead to properly control the filament temperature.

When using the UX-112 tube, slight changes will be necessary in the filament wiring, and in the "C" and "B" battery voltages: such changes being clearly illustrated in Figure 2. The small "C" battery must be taken out of the set and two flexible wires, approximately 12 inches long or more, must be connected to the terminals which previously connected the "C" battery. These connections will go to an external "C" battery consisting of three of the larger type "C" batteries connected in series.

To distinguish correct polarity it is advisable to connect a knot in the positive "C" battery lead as shown in Figure 4.

Practically no results will be had in reception unless the receiver is properly balanced. Consequently it is highly desirable to have an intelligent comprehension of the oscillator and frequency-changer circuits.

The function of these contained circuits is to change the incoming signal to a lower frequency, at which frequency it is amplified. The frequency to be amplified, in general practice, is the difference between the frequency of the broadcasting station and that of the oscillator. So to have a one-control superheterodyne, the tuning circuit of the frequency changing tube (first detector) and that of the oscillator must be so designed as to produce a constant difference in frequency at any setting of the controlling mechanism.

In this arrangement, when both the variable condensers are disconnected from the circuit, the design is such that the LC values of both circuits approximate each other. That is, the inductance (L) and distributed capacity (C) of the loop equals the inductance (L) and distributed capacity, plus half the capacity of the midget condenser (C).

When the condensers are again connected to the circuit and set at exactly the same capacity on the controlling mechanism, there should be exact resonance between the two circuits, from the minimum to the maximum range. Now, in order to obtain the desired frequency difference between the two circuits, the capacity of the midget condenser is increased which automatically lowers the frequency of the oscillator circuit.

There is a general opinion that meters on the panel of a radio receiver are in no-wise necessary to intelligent operation; but that they are employed merely as mechanical embellishments to give an appearance of intricacy. The opinion is erroneous.

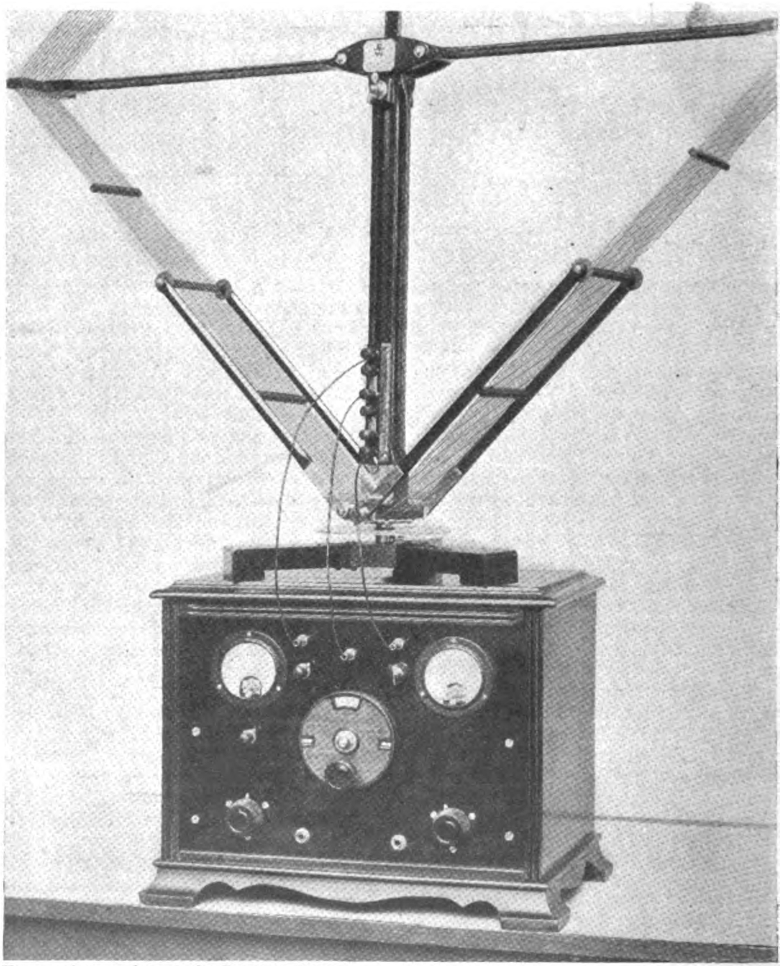
A slight increase above normal filament voltage, which increase may be detected only by a voltmeter, will produce a rapid deterioration of tube life. Going further, there is always a particular filament voltage for each receiver, which likewise can be determined only by the use of voltmeters or lucky guesses. Guesses may be relied upon if they have sufficed in the past. Voltmeters are accurate indicators. While the voltmeter detects an overloading of the filament, the milliammeter detects an overloading of the grid-plate circuits.

To obtain reception void of distortion the needle of the milliammeter should not vary from its normal settings. An overloading of one or more tubes may thus be detected by a fluctuation in plate-current of the milliammeter. To obtain satisfactory reception, watch your meters.

When high plate voltage is used, it is desirable to keep the DC current out of the loudspeaker windings by using a good make of output transformer, or an arrangement, illustrated in Figure 2 which consists of a 100 henry choke-coil and a 1 microfarad by-pass condenser.

It would be useless to build such a receiver as described and then connect it to an inferior loudspeaker.

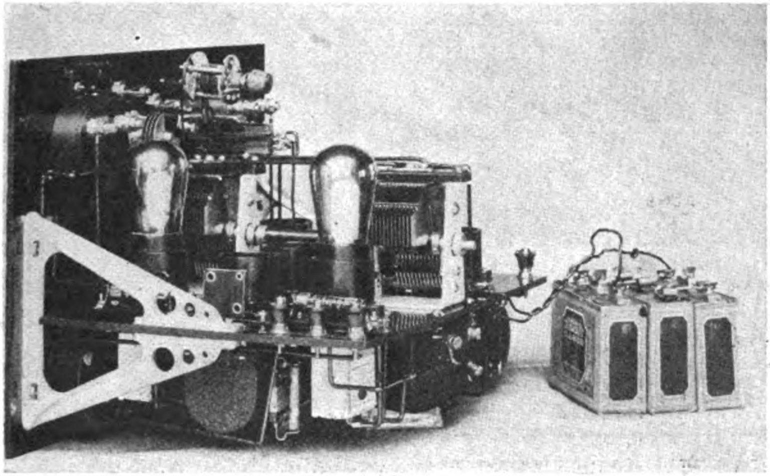
The owner of such a receiver, or any good make of receiver for that matter, should use a cone-type of speaker.



From a photograph made for POPULAR RADIO

THE NEW APPEARANCE OF THE RECEIVER

FIGURE 3: *Instead of the usual two terminals to the loop there are three now; and they terminate in small panel jacks on the set. An extra switch has been installed for changing the connections to the loop circuit. These are the only changes which are noticeable from the front of the receiver.*



A VIEW OF THE SET WITH THE CABINET REMOVED

Figure 4: *The "C" batteries which are connected with the flexible leads have been added to accomplish a saving in total "B" battery drain and also to improve quality on strong signals.*

How to Increase the Life of Your "B" Batteries

In almost any type of multi-tube receiver, which uses dry-cell "B" batteries for the high-voltage plate supply, considerable saving can be made by adjusting the filament rheostats or "B" battery voltage to provide only the needed sensitivity and volume.

A superheterodyne receiver, for instance, usually places a heavy drain on the "B" batteries, and of course provides great sensitivity and volume. However, when it is desired to tune in local stations there is no need for this great sensitivity and it is usually necessary to cut down volume by means of the potentiometer which controls the grid potential of the intermediate amplifier, or by cutting down the current supply to one or more of the tube filaments.

When volume reduction is accomplished by turning the potentiometer back from the oscillating point, the "B" battery consumption is greatly increased; therefore to cut down volume in this manner may increase "B" battery current as much as 25 percent. This is certainly not a logical procedure. To cut down volume by reducing the filament current is much more logical because this also reduces the drain on the "B" batteries, although not in proportion to the reduced signal strength. Moreover, it is necessary to cut the filament current to at least four of the tubes if any noticeable saving in "B" battery current is to be effected.

In the majority of cases the most advantageous way to cut down the "B" battery consumption is to reduce the voltage supplied to the plates of the amplifier tubes, especially the intermediate-frequency amplifier tubes. Actual measurements taken on one superheterodyne receiver show astonishing prolongation of "B" battery life resulting from reducing the detector and intermediate-frequency amplifier, plate voltages by 22½ volts. This particular receiver was designed to use 45 volts on the two detectors, 67½ volts on the four intermediate-amplifier tubes, and 90 volts on the two audio tubes. When used with 22½ volts on the detectors and 45 volts on the intermediate-frequency amplifier tubes, still retaining 90 volts on the audio-amplifier tubes, the "B" battery current consumption dropped to 74 percent of the original drain, which means that the life of "heavy duty" "B" batteries would be more than twice as great as when the original voltages were used.

In receivers of this type a "C" battery is usually used in connection with the audio amplifier, and for that reason the battery drain is comparatively small and little would be gained by reducing the plate voltage on the audio-amplifier tubes.

For long-distance reception results are not as good with the reduced voltage as with the original voltages. On local and semi-distant reception, however, results may be found better with the lower voltages because the volume of the output is reduced to more suitable proportions without the usual necessity for toning the receiver down, as is usually the case with local reception with superheterodyne receivers. Because of the somewhat decreased sensitivity when the lower voltages are used, the receiver is less noisy; it picks up less of the stray electrical disturbance in the neighborhood.

To put this plan into operation the "B—" leads from the receiver should be connected to lower taps on the "B" battery as shown in Figure 5. Try moving one lead at a time, to a point 22½ volts lower on the battery. It is best to do this while a fairly powerful local station is tuned in so that the effect on local reception can best be judged. During these tests it is well to keep the potentiometer adjusted fairly close up to the point of oscillation.

—S. GORDON TAYLOR

A Glossary of Practical Electrical Units

By William Fenwick

Ampere, (am'pĕr). The unit of current. It is defined as the unvarying current which will deposit silver at the rate of 0.001118 gram per second when it is passed through a solution of silver nitrate of standard specifications.

Ampere-Hour (am'pĕr our). A unit of quantity. The amount of electricity transferred by a current of 1 ampere in 1 hour = 3600 coulombs.

Ampere-Hours per Kilogram (am'pĕr ours per kĭl'o-grăm). The ratio of the ampere-hour capacity of a storage battery to the weight of its plates expressed in kilograms.

Ampere-Turn (am'pĕr tûrn.) A unit of magnetomotive-force). The magnetomotive-force exerted by a current of 1 ampere flowing through 1 turn.

Coulomb (cų-lōm'). The quantity of electricity transferred in 1 second by a current of 1 ampere.

Coulomb per Centimetre (cų-lŏm' per çĕn'ti-mē"-ter). The unit of electric displacement.

Farad (făr'ăd). The unit of capacity. The capacity of a condenser charged to a potential of 1 volt by 1 coulomb of electricity.

Gilbert (ğĭl'bert). The cgs unit of mangetomotive-force = 0.7958 ampere-turns.

Gilbert per Centimetre (ğĭl'bert per çĕn'ti-mē"-ter). The unit of magnetising force.

Henry (hĕn-ry). The unit of inductance. The inductance in which a variation of current at the rate of 1 ampere per second produces a counter electromotive-force of 1 volt.

Horsepower (hôrs'pow-er). A unit of work or power, equal to 746 watts.

Joule (joul). The unit of electrical energy. The energy expended in 1 second by a current flow of 1 ampere at an electrical pressure of 1 volt.

Maxwell (măks'-wĕl). The unit of magnetic flux.

Maxwell per Square Centimetre (măks'-wĕl per skwâr çĕn'-ti-mē"-ter). The unit of magnetic inductance.

Mho (mō). The unit of conductance. It is defined a the facility for current flow offered by a circuit of 1 ohm resistance.

Oersted (ō'ersted). The unit of magnetic reluctance. The reluctance offered when 1 gilbert micromicrofarad produces 1 maxwell.

Ohm (ōm). The unit of resistance, represented by the resistance offered to an unvarying current by a column of mercury 14.4521 grams in weight, of a constant cross-sectional area, of 106.3 centimetres in length, and of a temperature equal to that of melting ice.

Volt (vōlt). The unit of electromotive-force (electric pressure). It is defined as the electromotive-force which produces a current of 1 ampere when it is steadily applied to a conductor whose resistance is 1 ohm.

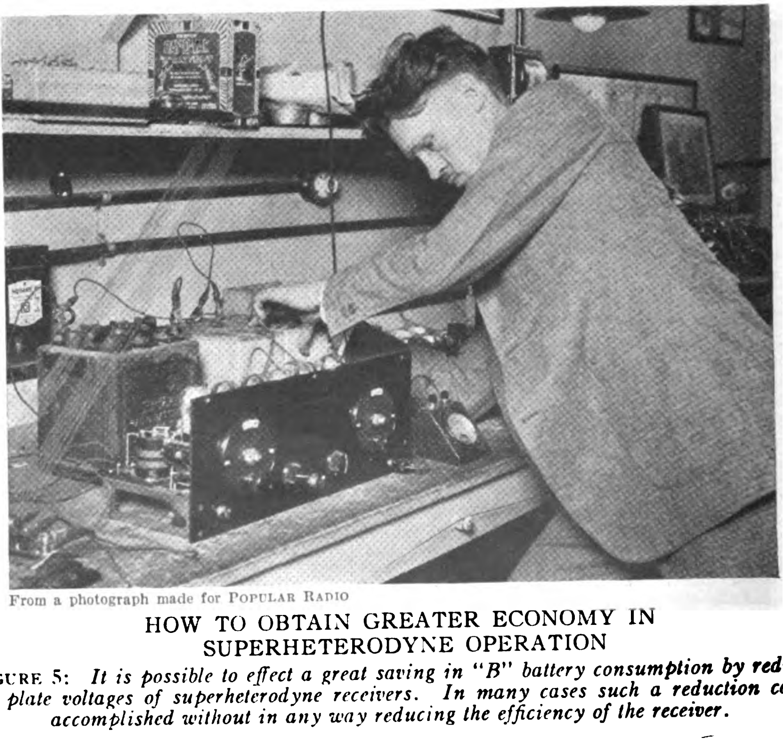
Volts per Centimetre (vōlts per çĕn'ti-mē"ter). The unit of electrostatic field intensity.

Watt (wat). The unit of work or power. It is defined as the expenditure of energy at the rate of 1 joule per second.

Watt-Hour (wat our). A unit of the quantity of electricity = 1 ampere-hour = 3600 coulombs.

As practically all of the units given above may be prefixed to indicate that they are multiplied by 10, 100, 1000 and so forth, or that they are divided by 10, 100 or 1000, the following prefixes are given. Column 1 gives their names; column 2 contains their abbreviations, and column 3 furnishes their meaning.

pico or micromicro	μμ	one million millionth
micro	μ	one millionth
milli	m	one thousandth
centi	c	one hundredth
deci	d	one tenth
deka	dk	ten
hekto	h	one hundred
kilo	k	one thousand
mega	M	one million



From a photograph made for POPULAR RADIO

HOW TO OBTAIN GREATER ECONOMY IN SUPERHETERODYNE OPERATION

FIGURE 5: *It is possible to effect a great saving in "B" battery consumption by reducing the plate voltages of superheterodyne receivers. In many cases such a reduction can be accomplished without in any way reducing the efficiency of the receiver.*

WITH THE INVENTORS

CONDUCTED BY WILLIAM G. H. FINCH

THIS *department will keep you in touch with the latest inventions of interest on which patent rights have been granted, and which are significant contributions to radio art.*

A New Variable Condenser for Short Wave Circuits

A NOVEL idea for a variable condenser which is especially adaptable for high frequency or short wave radio circuits is described in Patent No. 1,557,725, which was issued to John A. Proctor of Lexington, Mass.

The ideas contained in this invention are applicable to variable electrical condensers in general, and especially to the high potential condensers, which are used in radio transmitters and in power factor lines. However, the claims of the invention rest more particularly upon a variable condenser of the enclosed casing type which has preferably a vacuum dielectric and which is provided with means for varying the condenser capacity by relative movements of the condenser conductors or armatures of opposite polarity. The condenser may be constructed so as to be suitable for use at any desired voltage.

In condensers of the sheet or jar type now in use, the electrical losses where high voltages are employed are comparatively great. This results in a loss of efficiency and also in the over-heating and ultimate disintegration of the condenser, especially if it is not properly made. This heating is partly due to losses in the dielectric which apparently arise from dielectric hysteresis or frictionally impeded movements of the atoms of the dielectric because of electric flux through the latter, and partly because of brush or corona discharges in the medium surrounding this type of condenser.

An object of the present invention is to provide a condenser construction in which losses are at a minimum. In particular, the invention comprises a variable condenser in which the principal dielectric preferably is a vacuum.

Briefly this condenser comprises a suitable casing, bulb or tube in which is mounted a condenser made up of spaced metallic plates. The air is exhausted from the casing to form between the plates a vacuum dielectric in which there is no appreciable loss in use due to gas ionization or to dielectric hysteresis. Finally, there are means, operable from the exterior of the casing, by which relative movement of the interior condenser conductors may be effected.

The invention is shown, in perspective, in Figure 1.

The condenser contains spaced and fixed metal plates mounted upon and electrically connected to metal rods. These plates are spaced from each other by any suitable means. The rods are in turn secured to metal end plates.

Movable metal plates are fixed at spaced distances on a metal shaft and in such a position as to alternate with the fixed plates. The shaft is journaled in insulators which are fixed in the end plates to insulate the two sets of plates from each other.

The upper portions of the end plates are cut away in order that the movable plates may be sufficiently spaced from them. This allows a wider range of capacity variation, as plates in the position shown will have very little capacity effect.

Two springs made of strips of metal are connected to the end plates and engage the side walls of the enclosing air-tight glass bulb or casing. In this way the condenser is yieldingly supported against any longitudinal movement which might injure the casing. This casing may be a bulb or tube as shown and it should preferably be of glass or some other non-magnetic material.

There are several features of this condenser which may be pointed out as particularly novel. (The numerals mentioned correspond to those which mark the parts in Figure 1.). One terminal (that for the fixed plates, 25) is a conductor, 36, which extends through and is sealed in the casing, 32a. The terminal is thus connected to one of the two metal springs, 32, which is connected to the metal plates, 28, which, in turn, are electrically connected to the fixed plate, 25.

The other terminal of the condenser (that for the movable plates, 29) is a conductor, 38, which extends through and is sealed in the casing, 32a. This terminal is then connected to a spiral conducting coil, 37, which is connected to one end of the metal shaft, 30. This connection is of flexible wire to allow the free rotation of shaft, 30, which carries the movable conductors.

The parts of the terminals, 36, and 38, which extend through the casing, 32a, and are fixedly sealed there should be of platinum when the casing is of glass. Thus these terminal leads are independent of the capacity-varying means which are now to be described.

The left end of the shaft, 30, terminates in a magnet, 39, which is made of some suitable magnetic material such as iron, steel or nickel, and which is supported in a spaced relation to the end of the tube, 32a. This magnet has poles 40 and 41. The encased condenser is supported in any suitable manner on the base, 42.

A horseshoe magnet, 43, is located outside the casing, 32a, is journaled in the support, 42, at 44 and is provided with an actuating knob, 45. This magnet embraces the end of the non-magnetic casing, 32a, which is adjacent to the exterior magnet, 39. As the magnet, 43, is rotated, this rotation will be communicated magnetically to the variable condenser through the co-acting interior magnet, 39.

In this way means are provided for varying the capacity of the condenser without any danger of impairing the high degree of vacuum necessary or, in any instance, without the necessity of extending a mechanically moving part through the casing, 32a.

Either of the magnets may have a soft iron or nickel armature, if this is desired.

The movable plates, 29, are unbalanced on their shaft, 30, and tend (when their axis, 30, is horizontal, as shown) to hang down under the influence of gravity in a position 180 degrees from that shown in the drawing. Therefore, the capacity of this condenser may be varied by rotating the casing, 32a (and consequently the fixed plates, 25) around the longitudinal axis of the casing. The movable plates will hang down by gravity and will remain stationary.

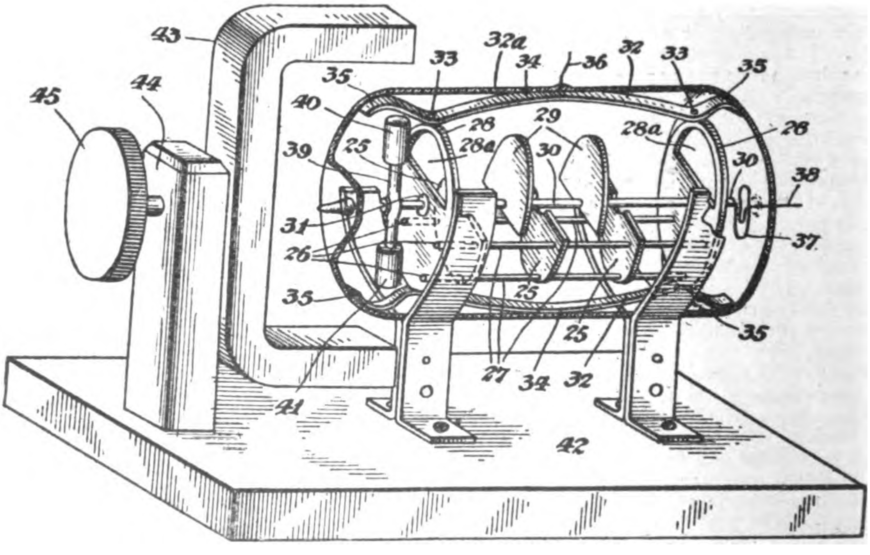
Thus the capacity of the condenser may be varied with or without the operation of a magnetic field, by a rotation of the entire casing, 32a, in its supports; and each of the relatively movable conductors may be moved with respect to the other.

The order of vacuum or exhaustion which exists in a condenser which contains a dielectric such as the one described above should be extremely high so that no appreciable gas ionization may take place to cause losses while the condenser is in operation. This condition may be obtained, for example, by a pressure of the order of a millionth of a millimeter. Exhaustion of this order may be obtained by any well-known means such as a Gaede or molecular pump or by Langmuir's condensation pump.

All of the materials inside of the casing, when a vacuum dielectric is employed, should be treated to remove gases (occluded or otherwise) according to any of the well-known processes in use for the production of high vacuum apparatus. This treatment may consist, for example, in removing gases from these materials before they are assembled in the casing.

In addition, it is advisable to subject the contained materials, after they are assembled in the casing, to further treatment to remove any residual gases. This final treatment may consist of a bombardment of the materials from a heated filament which is temporarily located within the casing.

The gases may best be removed in the first treatment by the use of the Northrup high frequency electrical furnace. If this method is used, the entire condenser is placed in the field



A NEW VARIABLE CONDENSER OF UNUSUAL DESIGN

FIGURE 1: *This diagram shows how the condenser is rotated by means of the magnetic attraction between the large rotatable member and the small pole pieces. This method of operation makes it possible to mount the moving parts of the condenser completely within a vacuum tube.*

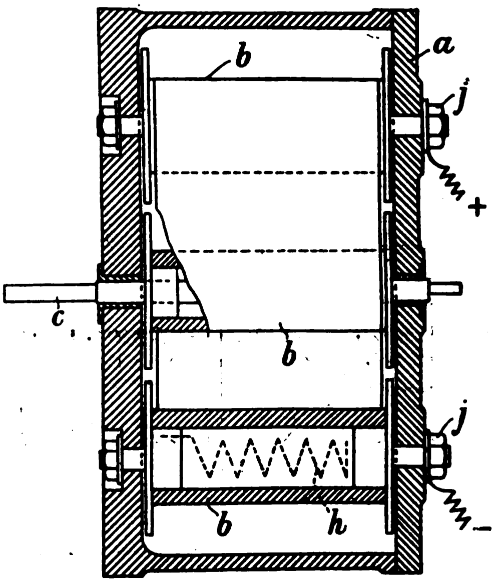
of a coil carrying a high frequency current, while it is undergoing the process of exhaustion. This heats the metal parts inside the condenser casing, and thus drives off all gases which may be in them before the casing is completely exhausted and sealed off.

The materials used in these vacuum condensers should be of such a nature that the gases may be easily removed by the two processes described above. Nickel, tungsten, molybdenum or rolled steel should be used wherever possible in the construction of the condensers.

In the way described above, a condenser in which the plates 1 and 2 are spaced a centimeter apart, may be constructed to stand a million volts. In such a condenser and with a vacuum dielectric of the order specified, the total loss is practically zero as it is limited to the minute Joulean losses in the metal plates and leads, and to the minute losses in the dielectric surrounding the terminals and in the supporting dielectric material.

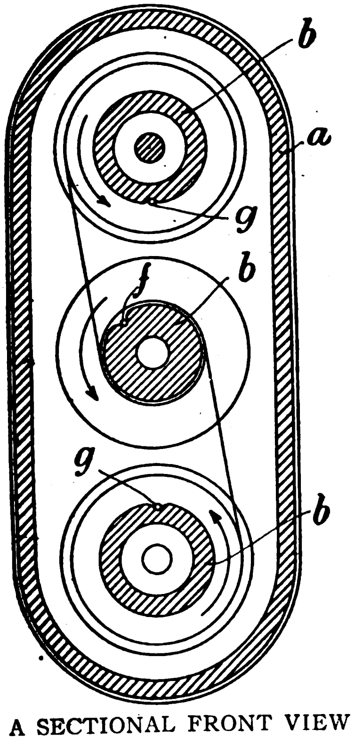
The most important aspect of this invention is that part of its construction and arrangement which involves the variation of the condenser capacity by means of relative movements of the conducting plates inside of the casing where they are separated from one another by any suitable dielectric. Another particularly important aspect of the invention when a vacuum is employed, as the dielectric, or when the relatively movable conductors are wholly supported and enclosed within the casing, is the provision of a means for causing relative movements of the conducting plates which does not affect the vacuum seal or the enclosure of the casing.

Sixteen claims were allowed to Mr. Proctor on this novel and ingenious invention.



A SECTION OF THE SELF-INDUCTANCE

FIGURE 2: *This diagram shows how the convolutions of the coil wind about the three roller cores of this new variable self-inductance.*



A SECTIONAL FRONT VIEW

FIGURE 3: *This view of the self-inductance described, shows how the wires roll on and off of the roller cores.*

A New Variable Self-Inductance

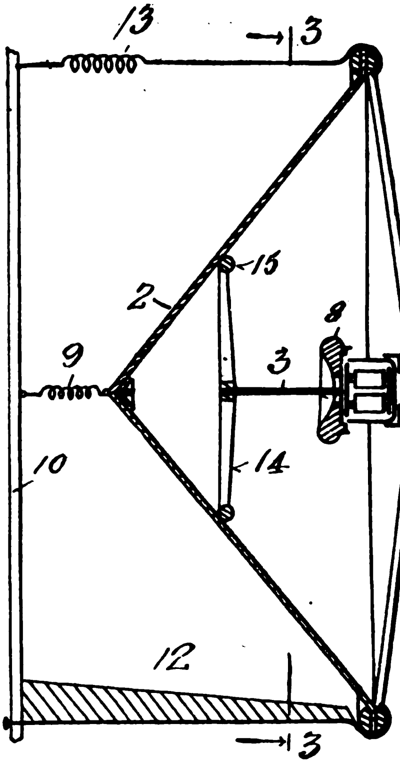
A VARIABLE self-induction apparatus, which is simple in operation and in construction, is described in Patent No. 1,555,509, which was issued to Yves Marrec of London.

In this invention an electrical conductor, which may be a wire or flat metal strip, is fastened at the middle of its length to a winding element which is referred to, in the description, as the middle winding element. The two ends of the wire or strip are adapted to be simultaneously wound on two other winding elements, which are referred to as the end winding elements.

In an arrangement of this sort, the length of the conductor which is coiled on the middle winding element has practically no self-induction, as it is a non-inductive winding, the magnetic fluxes of which, being opposite, neutralize one another. On the other hand, the two separate lengths of single conductor which are coiled on the end winding elements constitute a coil in which the self-induction varies with the length of the conductor wound on these elements.

It is evident that by varying the amount wound on the several winding elements, the self-induction of the conductor may be varied continuously from practically nothing, when almost the whole of the wire is wound on the middle winding element, to a maximum when the wire is entirely unwound from it.

The conductor should usually have a round, square or rectangular cross-section and it should



A NEW CONE-TYPE LOUDSPEAKER

FIGURE 4: *The constructional details of De Forest's new cone-type loudspeaker which may be used in connection with an electrical sound receiving apparatus such as a telephone receiver.*

be wound so as to form helices, in which the diameter and pitch and therefore the self-induction will depend on the shape and size of the winding elements. In this case, the winding elements should be provided with grooves which have been adapted to receive the conductor. The conductor may, however, be flat, and wound so as to form spirals.

The drums which constitute the end winding elements may be of magnetic material, so as to constitute magnetic cores. These cores may be independent.

The faces of the casing in which the spindles of the winding elements are pivoted may also be of magnetic material. If they are, they will form a closed magnetic circuit with the cores.

Figure 2 shows a section of the variable self-induction apparatus described in this patent. Figure 3 shows a sectional front view.

The form of the apparatus which is shown has a case, which may be of any suitable non-conducting material and three drums, which are carried in bearings. The spindle on which the middle drum is carried is extended, as shown in the diagram and an adjusting knob is fitted upon it (the knob is not shown).

The strips are made from thin silk; and each carries the conductor on one side and a more or less coarse woven mesh on the other side.

The conductors may be of metal foil, in which case they are bound and stitched at the edges as shown. However they may be made from sprayed metal, metallic paint or other materials.

There are two strips which are both pinned to the central drum and to the end drums. The non-conducting part of the strip may be continuous and may be carried under an anchoring wire on the middle drum.

The two end drums are hollow and contain springs which keep the strips in tension and unwind them from the middle drum when this is turned in the reverse direction.

The spindles of the end drums carry terminals by means of which a potential difference is applied to the coatings.

A Cone-type Loudspeaker on a New Principle

DR. LEE DE FOREST, the eminent radio pioneer, was recently granted patents No. 1,554,794 and No. 1,552,914 for a cone type of loudspeaker.

Among loudspeaking devices are those in which the sound is led from its source into a second horn or cone of tightly stretched paper, thin leather or other non-metallic material for transmitting sound waves. Several such horns are being used, in connection with phonographs, in which the phonograph needle is located at the apex of the cone.

It is one of the special purposes of Dr. De Forest's invention to provide a loudspeaking device that uses this type of diaphragm or cone but which operates on a different principle and therefore is made available for use in connection with an electrical sound receiving apparatus—such, for example, as a telephone receiver.

Dr. De Forest employs a cone structure shown in Figure 4. It consists essentially of a spider, preferably with a comparatively heavy rim, between parts of which is clamped a non-metallic diaphragm such as parchment, paper or thin leather. This diaphragm is stretched preferably in the shape of a cone. It may be maintained in a taut position in any suitable manner, for example, by means of a rod terminating at one end in a spider which supports a ring secured to it, which engages it one-half or one-third of the distance from the apex of the cone to the periphery. The rod is provided with screw threads at the opposite end which engage a nut positioned inside of the hub of the spider.

It will be seen that by varying the position of the nut which is on the threaded portion of the rod the tension imparted to the diaphragm may be varied, thus permitting an easy manner of maintaining the diaphragm taut under all conditions of temperature or atmosphere.

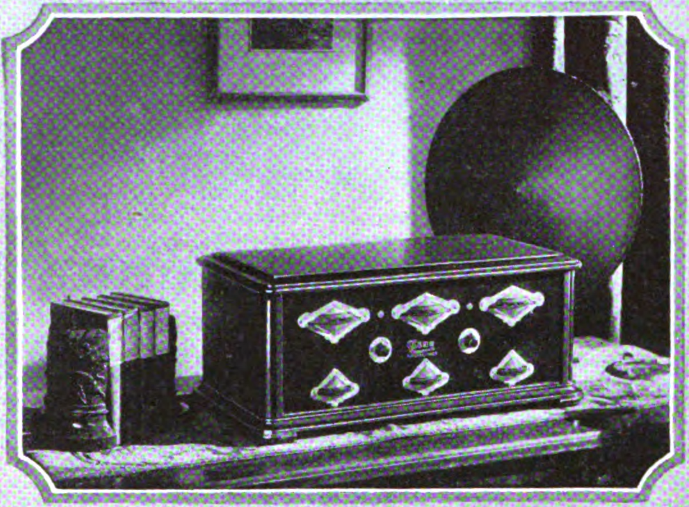
The apex of the conical diaphragm is provided with a needle point that projects through the diaphragm. This needle point is placed in contact with the diaphragm of an ordinary telephone receiver. It will be seen that the vibrations imparted to the diaphragm of the telephone receiver are sent directly to the conical diaphragm. In this way, the sound, in a greatly amplified condition, is reproduced in an undistorted non-metallic manner.

It is written:

"To see oneself is to be clear-sighted."

The clear-sighted see past the beautiful exterior of the Synchrophase to the true virtue within.

Doctor Mu



For Those Who Understand and Appreciate Quality
—in Reception
—in Construction

THE appearance of the inside of radio receivers reveals little or nothing to the uninitiated. But men who are "radio-wise" see a vast difference in set construction.

By the former the ear only can be used in judgment; to the latter, the eye tells almost as much as the ear.

Look inside a Grebe Synchrophase. Your eye will be as delighted with the quality of construction as the ear will be satisfied with the superior receptivity, which this construction not only makes possible but maintains.

Ask your dealer to demonstrate.

A. H. Grebe & Co., Inc., 109 West 57th Street, New York
Factory: Richmond Hill, N. Y.
Western Branch: 443 So. San Pedro St., Los Angeles, Cal.

This company owns and operates stations WAHG and WBOQ; also low-wave re-broadcasting stations, mobile WGMU and marine WRMU.

Exclusive Grebe Developments:

Grebe "Colortone"

Flexible Unit Control

Binocular Coils
Reg. U. S. Pat. Off.
and
Low-wave Extension Circuits

Ask how and why they make Grebe reception so superior and dependable.

The GREBE SYNCHROPHASE
TRADE MARK REG. U.S. PAT. OFF.

GREBE RADIO
TRADE MARK REG. U.S. PAT. OFF.

All Grebe apparatus is covered by patents granted and pending.

PAGES WITH THE EDITOR

The avalanche of letters and questionnaires that have descended upon the Editor as the result of his appeal (published in this department of the February number) for opinions on the relative merits of the various editorial features that appear in Popular Radio have given incontrovertible evidence of the extraordinary personal interest that our readers take in the magazine.

* * *

While the personal contact between readers and members of the staff of Popular Radio have always been many, never before have such a large number written in at one time to give us the benefit of their suggestions and opinions. The staff is still struggling to handle the correspondence that has, during the past few weeks, literally piled into the sanctum.

* * *

Both the questionnaires as well as the letters that accompanied them are of very great value indeed in determining the plans and policies of Popular Radio. For it is obvious that the more closely in touch with the readers the editors can get, the better can the editors learn the desires and needs of the readers—and consequently the more efficiently may the demands of the public be met.

Photo by Clarence White

THE DESIGNER OF THE POPULAR RADIO MEDAL FOR CONSPICUOUS SERVICE

Walter D. Teague, one of the foremost designers in America, was for two years president of the Artist's Guild and has twice been awarded the coveted medal by the Art Directors Club for decorative design.

To the hundreds of friends and critics who took the time and trouble to express their opinions, the gratitude of Popular Radio is here extended. That their efforts have not been made in vain will be demonstrated in a practical manner in the future issues of the magazine.

* * *

Beginning, for example, with the very next number!

* * *

With the coming issue of Popular Radio—the May number—this magazine will celebrate its fourth birthday with a big special Anniversary Number.

* * *

The happy occasion will be observed not only by an issue that will contain a much larger amount of reading matter and larger illustrations than have ever appeared in the magazine, but by a permanent increase in the page size from the present "standard" size (6¾ by 10 inches) to the "flat" size (8⅛ by 11¼ inches).

* * *

This increase in the page size of Popular Radio, aside from the opportunities it gives for reproducing the circuit and constructional diagrams and charts on a larger scale, also makes it possible to print the magazine on presses that print in colors.

* * *

Beginning *with the May number, therefore,* Popular Radio *will be printed in colors.*

* * *

This innovation will permit the reproduction of the more important constructional diagrams in blue-print form and the *facsimile* reproduction in color of graphs—an improvement that will be appreciated particularly by the experimenter who makes practical use of these essentially practical illustrations.

* * *

With this issue the first formal announcement is made (on page 363) of the institution of the Popular Radio Medal for Conspicuous Service—a form of recognition to amateurs which Popular Radio has long had in contemplation and preparation.

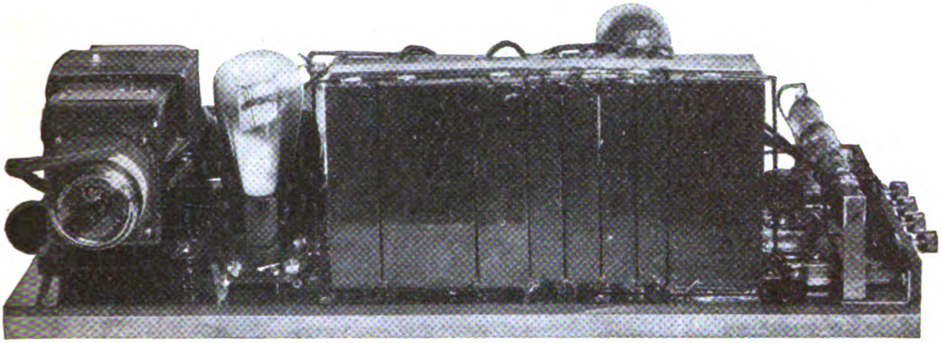
* * *

The enthusiastic response that Popular Radio met when it first advanced the idea of instituting such a medal can be no better evidenced than in the character of the personnel of the Committee of Awards and of the Advisory Committee, which include some of the foremost men and women engaged in public service, in scientific work and in the radio art.

* * *

Readers are not merely invited but urged to notify the Committee of Awards of anyone who, in their belief, is entitled to the recog-

(*Continued on page* 6)



Power Amplification --without "B" Batteries

DUBILIER
CONDENSER
TYPE
Cap.
D.C. test V.
D.C. Wk. V.
A.C. Wk. V.
Dubilier
New York N.Y.
U.S.A.

For the filter circuits in "B" battery eliminators use only Dubilier Filter Condensers.

Dubilier Filter Condensers are used in the Laboratory Model of the new Power-Pack Amplifier, designed by Albert G. Craig, because of the unusually high voltages developed in this circuit.

These condensers are especially designed for use in filter circuits. They will give permanent service at their rated working voltages and lifetime satisfaction to those who use them as specified.

Insist on getting Dubilier filter condensers. If your dealer cannot supply you, write directly to us.

Dubilier
CONDENSER AND RADIO CORPORATION

4377 Bronx Boulevard, New York, N. Y.

(*Continued from page* 4)

nition that the award of the Popular Radio Medal for Conspicuous Service will confer.

* * *

"Having read the latest issue of POPULAR RADIO from cover to cover, I have come to the conclusion that simple language is used throughout, and that all of the articles are written so clearly that a person who doesn't know a thing about radio can readily understand them. . . . POPULAR RADIO is certainly one of the outstanding radio publications of the present time."

—WILLIAM D. SLADE, *Brooklyn, N. Y.*

* * *

WHO among our readers have observed the effect of radio reception on wild animals? Numerous experiments have been made on animals in captivity with conclusive results, but here is a letter from a reader who is an experienced deer hunter and who suggests a unique use of radio as a lure for wild game:

"*As a reader of* POPULAR RADIO *I would like to advise my huntsmen friends, through your magazine—particularly those who go deer hunting every season—to instruct their guides to set up radio receiving sets in their favorite hunting grounds once or twice a week, and to tune in during the night. They may be surprised to learn that every season the male deer (with three-inch horns) will follow these radio concerts, and will leave other districts for miles and miles around.*

FREDERICK W. KERTEL,
Hunter in the Adirondacks.

"*P. S. It is not against the law to coax the game away from other districts.*"

Kendall Banning—

Editor, POPULAR RADIO

From a photo made for POPULAR RADIO

TESTING THE ACCURACY OF THE WAVELENGTH SCALE ON A READY-MADE RECEIVER

Intensive experimental work in the POPULAR RADIO LABORATORY *furnishes the material for many of the series of articles which are published in the magazine under the title "How to Get the Most Out of Your Ready-made Receiver." Here Mr. Taylor is engaged in obtaining data on the Ferguson set which will appear in the next number—for May.*

"Your radio is always top notch. What do you do to keep it so full of pep?"

KEEPING your "B" batteries full of pep, without frequent renewals, is simply a matter of using the right size Evereadys for your particular set with a "C" battery*.

The rule which determines the right size "B" batteries to use is simple, and once learned definitely settles the question of "B" battery service and economy.

On 1 to 3 tubes—Use Eveready No. 772.

On 4 or more tubes—Use the Heavy Duty "B" Batteries, either No. 770, or the even longer-lived Eveready Layerbilt No. 486.

On all but single tube sets — Use a "C" battery.

When following these rules, No. 772, on 1 to 3 tube sets, will last for a year or more; and Heavy Duties, on sets of 4 or more tubes, for 8 months or longer.

These life figures are based on the established fact that the average year-round use of a set is 2 hours a day.

A pair of Eveready No. 772's for a 5-tube set instead of 2 Eveready No. 770's or 2 Eveready Layerbilts No. 486—looks at first glance like an economy because of lower first cost. But in a few months the 772's will be exhausted and have to be replaced. After the same length of time the Eveready No 770's or the Eveready Layerbilts No. 486 will still be good for many more months of service.

We have prepared for your individual use a new booklet, "Choosing and Using the Right Radio Batteries," which we will be glad to send you upon request. This booklet also tells about the proper battery equipment for use with the new power tubes.

LEFT—*No. 486, for 4, 5 or more tubes.* $5.50

RIGHT—*Eveready Dry Cell Radio "A" Battery, 1½ volts.*

EVEREADY
Radio Batteries
-they last longer

*NOTE: In addition to the increased life which an Eveready "C" Battery gives to your "B" batteries, it will add a quality of reception unobtainable without it.

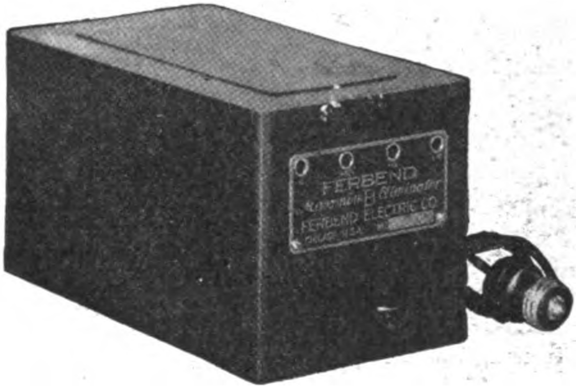
Manufactured and guaranteed by
NATIONAL CARBON CO., INC.
New York San Francisco
Canadian National Carbon Co., Limited, Toronto, Ontario

Tuesday night means Eveready Hour—9 P. M., Eastern Standard Time, through the following stations:

WEAF—*New York*	WSAI—*Cincinnati*
WJAR—*Providence*	WEAR—*Cleveland*
WEEI—*Boston*	WWJ—*Detroit*
WTAG—*Worcester*	WGN—*Chicago*
WFI—*Philadelphia*	WOC—*Davenport*
WGR—*Buffalo*	WCCO—*Minn.* *St. Paul*
WCAE—*Pittsburgh*	
KSD—*St. Louis*	

Pacific Coast, Eveready Program
KGO—*San Francisco*, 8 *to* 9 *P. M.*

Within Reach of All



Unconditionally Guaranteed to be equal or superior to any Eliminator on the market, regardless of price.

Complete, nothing else to buy. Supplied in two models, one for Direct and the other for Alternating Current.

A. C. Model, price $12.50
D. C. Model, price . . . . . $ 9.75

$12.50

FERBEND "B" ELIMINATOR

Operates at a maximum efficiency at all times. Noiseless—no hum. Taps at 22½—45—90 volts.

Maximum voltage, 100. (for 135 volts, simply add a 45 volt "B" battery.)

A. C. model gives ***Full Wave Rectification.*** Cost of operation less than 50c a year. Lasts indefinitely.

All parts are specially designed and manufactured by us for this purpose only.

Unconditionally Guaranteed
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Ferbend Electric Co.
419 W. Superior St., Chicago

☐ Send at once. Payment enclosed.
☐ Send C. O. D. ☐ Send Literature.
☐ Send A. C. Model. ☐ Send D.C. Model.

Name ....
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Superior Results!

FERBEND
Wave Trap

This company also manufactures the famous Ferbend WAVE TRAP—the instrument which has been widely imitated but never equalled. It is the only original and genuine.

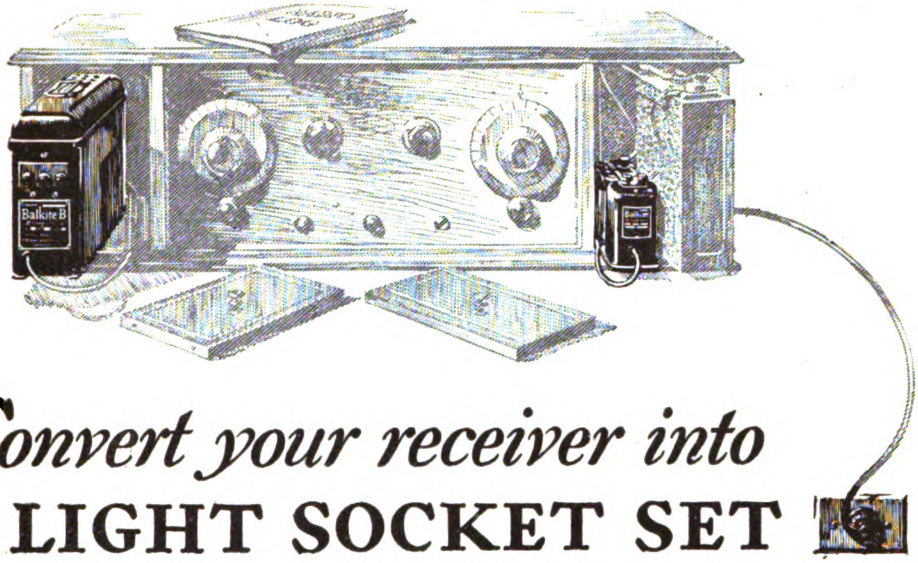
Now you can get permanent and efficient "B" current supply direct from your electric light socket at a price scarcely higher than new "B" batteries. Ferbend has succeeded in combining ***results*** with first-cost economy, for your benefit. Equip your set NOW with this wonderful new instrument and be convinced.

Ask Your Dealer or Send Direct

If you prefer, we will make shipment direct to you upon receipt of price, or C.O.D. if desired. Remember, ***superior results are guaranteed or your money back.*** USE THE COUPON NOW!

FERBEND ELECTRIC CO.
419 W. Superior St., Chicago, Ill.

Ferbend Maxmin "B" Eliminator



Convert your receiver into A LIGHT SOCKET SET *with* Balkite Radio Power Units

Now you need wait no longer for a light socket set. Balkite Radio Power Units—the Balkite Trickle Charger and Balkite "B"—enable you to make a light socket set of your present receiver.

The Balkite Trickle Charger converts your "A" Battery into an automatic "A" power unit that furnishes full "A" current from the light socket at all times. Balkite "B" replaces "B" batteries entirely and furnishes "B" current from the light socket.

This popular light socket installation is extremely simple to install, economical both in initial cost and in operation, and will fit in practically all present battery compartments. It is composed entirely of units that have demonstrated their success over a long period of time.

Noiseless—No bulbs—Permanent

All Balkite Radio Power Units are permanent, entirely noiseless, have no bulbs, no moving parts, nothing to break or get out of order. Their current consumption is very low. All operate from 110-120 volt AC current, with models for 50, 60 and other cycles. *All are tested and listed as standard by the Underwriters' Laboratories.* . . . At your dealer's.

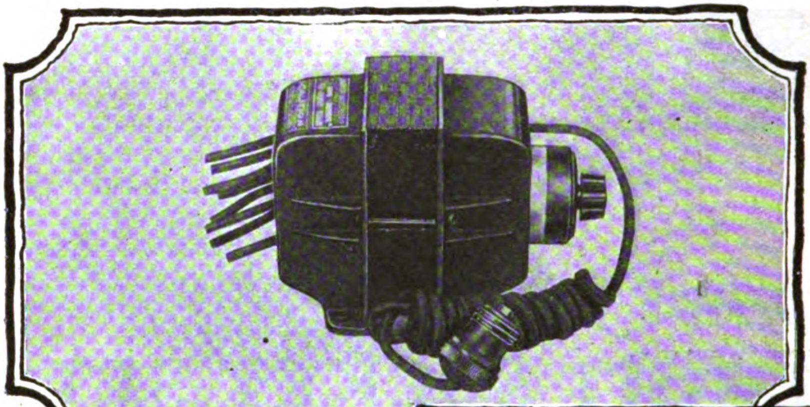
[***The Balkite Railway Signal Rectifier is now standard equipment on over 50 leading American and Canadian Railroads***]

FANSTEEL
Balkite
Radio Power Units

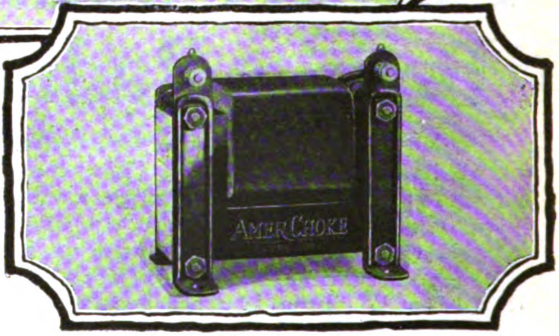
MANUFACTURED BY FANSTEEL PRODUCTS COMPANY, INC., NORTH CHICAGO, ILLINOIS

Sole Licensees in the United Kingdom: Messrs. Radio Accessories Ltd., 9-13 Hythe Rd., Willesden, London, N. W. 10

American Transformer Company



AmerTran Power Transformer Type PF-52



AmerChoke. Type 854.

FOR more than twenty-five years, the American Transformer Company has specialized in the manufacture of transformers. The transformers used by Marconi in his first trans-Atlantic tests in 1904 were made by this Company.

Since that time the engineering staff has directed a large share of its resources toward the development of transformers for radio use.

In 1921 the AmerTran Audio Transformer set a definite standard of excellence in its field.

The last five years have seen radio develop rapidly. Better tubes, broadcasting, and acoustical apparatus have brought these phases of reproduction nearer to perfection than ordinary transformer, impedance, or resistance audio amplification.

Transformer Builders

American Transformer Company

When the new AmerTran DeLuxe Audio Transformer was recently introduced it put the "audio side" ahead of broadcasting facilities and reproducing instruments. Faithful amplification with natural quality thus, has again established AmerTran as the mark of a "new standard of excellence." Combined with the new tubes, cone speakers, and clear signals from the detector tube, the AmerTran DeLuxe will reproduce natural volume over the *entire* audible range.

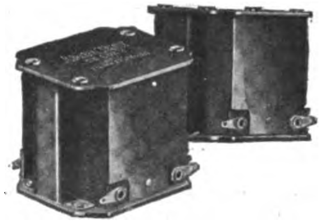
And now, as Radio Reception is further simplified and refined, the American Transformer Company offers a major contribution.

The AmerTran Power Transformer and the AmerChoke make it possible and economical to use the new 7½ volt power tubes in the last audio stage. The filament of this tube is lighted direct from this transformer. The Power Transformer also has a filament supply winding for the rectifying tube and supplies sufficient plate current, after rectification, for the operation of the entire receiving set.

As the receiving set of the future is destined to be power operated—the American Transformer Company offers the above apparatus as units which in quality and design are best adapted for use in the type of audio amplifier required.

For use in building, experimenting and manufacturing these new AmerTran Radio Products assure dependability and satisfaction —and furnish the most advanced construction in practical radio.

AmerTran DeLuxe 1st Stage . . .	**$10.00**
AmerTran DeLuxe 2d Stage . . .	**10.00**
AmerTran AF-7 (3-½-1)	**5.00**
AmerTran AF-6 (5-1)	**5.00**
AmerTran Power Trans. PF-45 .	**15.00**
AmerTran Power Trans. PF-52 .	**18.00**
AmerChoke Type 854	**6.00**



AmerTran DeLuxe two types for first and second stages.

Write for booklet entitled "Improving the audio Amplifier." It contains valuable up-to-date information.

DEALERS: The sale of AmerTran Radio Products East of the Rockies is handled exclusively by the AmerTran Sales Company, Inc., 178 Emmet Street, Newark, N. J. Direct to dealer sales policy. Some territories are available for parts dealers and service stations.

Sold only at Authorized AmerTran Dealers

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178 Emmet Street, Newark, N. J.

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Send coupon below for FREE BOOK—"Rich Rewards in Radio." Read for yourself. No previous experience needed. Common schooling enough. WRITE NOW.

You get all these sets

Receiving sets, from simplest kind to thousand mile receiver, included to help you learn. An UNEQUALLED OFFER. Other special features for limited time only, so ACT QUICK!

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CARTER

All Metal "IMP" Rheostat

(Pat. Pend.)

Half Size

$1 **All Resistances 3 to 50 Ohms**

No matter what circuit you use, use a Carter "IMP" Rheostat. No moulded parts to crack or break; wire element clamped in place. Will not move. Silent, smooth operation. Potentiometer 200 or 400 Ohms; same size and construction. Price $1.25.

MEMBER R.M.A. See them at your dealers. Write for illustrated folder.

In Canada—Carter Radio Co., Limited, Toronto

Carter Radio Co.
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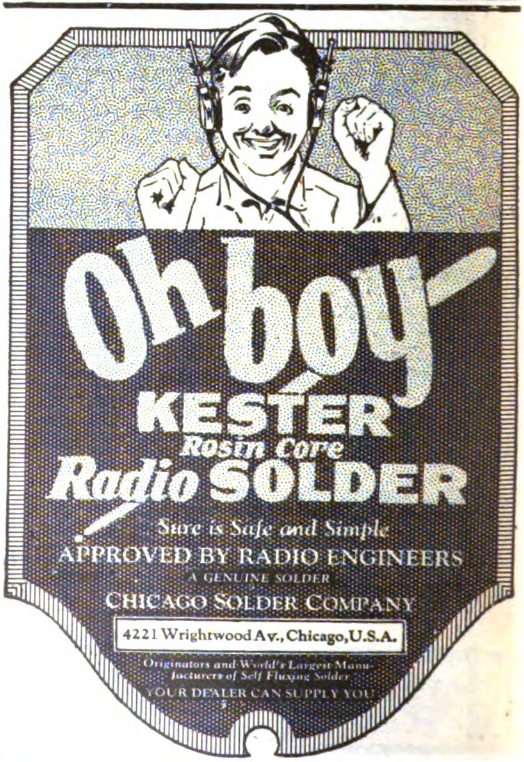
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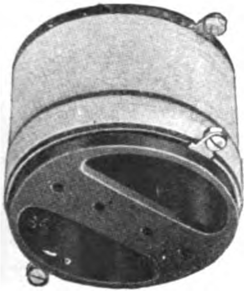
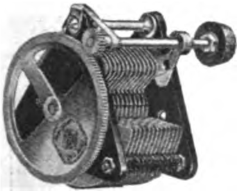
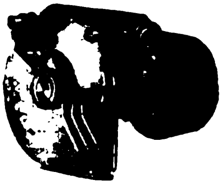


Type 277-D
Coupling Coil
Price $1.50



Type 247-H
Geared Condenser
Price $5.00



Type 368
Micro-Condenser
Price $1.25

In building a radio receiver remember that its performance depends primarily upon two things; an efficient circuit, and the use of good parts.

Wherever you find a popular circuit you will invariably find General Radio parts.

The General Radio Company has contributed more in scientific apparatus for laboratory use than any other one Company in the history of radio.

The same outstanding craftsmanship and materials are embodied in General Radio parts for use in the construction of broadcast receivers.

Through the merits of design, performance, and price, General Radio instruments for the scientist or set-builder are universally recognized as the Standards of Quality.

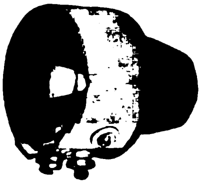
Every instrument made by the General Radio Company is thoroughly guaranteed.

The General Radio Company has endeavored to make it possible for the experimenter to obtain its products with a minimum of effort. A careful selection of distributors and dealers has been made. They are best fitted to serve you. If, however, you are unable to obtain our products in your particular locality they will be delivered to you, postpaid, direct from the factory upon receipt of list price.

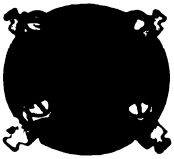
Write for our latest parts
Catalog 924P

GENERAL RADIO Co
Cambridge 39, Mass.

Type 285
Audio Transformer
6 to 1 and 2 to 1
Price $6.00



Type 301
Rheostats
12 and 25 ohms

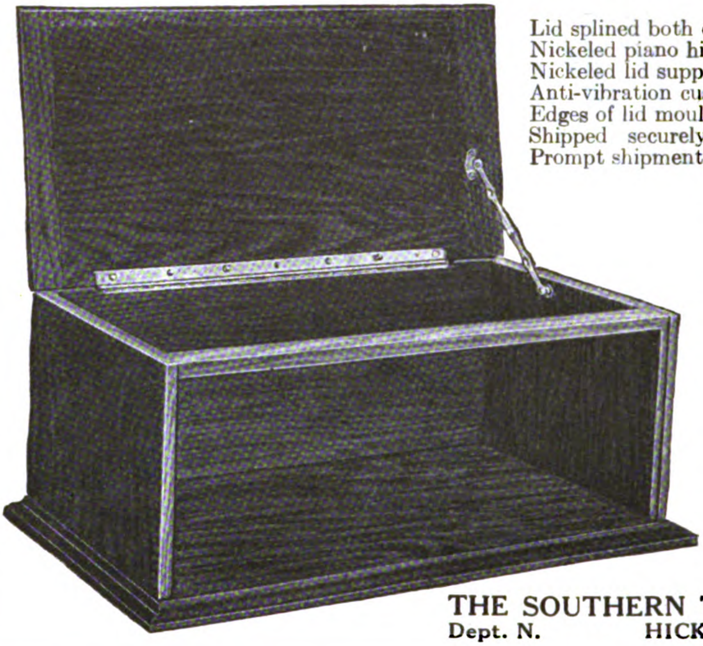


Type 349
Ux Tube Socket
Price 50c.

GENERAL RADIO
INSTRUMENTS

"Behind the Panels of Better Built Sets"

A RADIO CABINET OF BEAUTY AND ELEGANCE DIRECT TO YOU AT LOWEST COST



Lid splined both ends to prevent warping.
Nickeled piano hinge—Full length.
Nickeled lid support of artistic design.
Anti-vibration cushion feet (not vis.ble in cut).
Edges of lid moulded to match bottom.
Shipped securely packed in strong carton.
Prompt shipment. Big stock for holidays.

	Hardwood, Rubbed Mahogany Finish	Solid Black American Walnut
7 x 18 x 7½ *or* 10 in. deep	$3.50	$5.00
7 x 21 x 7½ *or* 10 in. deep	3.75	5.25
7 x 24 x 7½ *or* 10 in deep	4.00	5.50
7 x 26 x 7½ *or* 10 in. deep	4.75	6.25
7 x 28 x 7½ *or* 10 in. deep	5.50	7.00
7 x 30 x 7½ *or* 10 in. deep	6.00	8.00

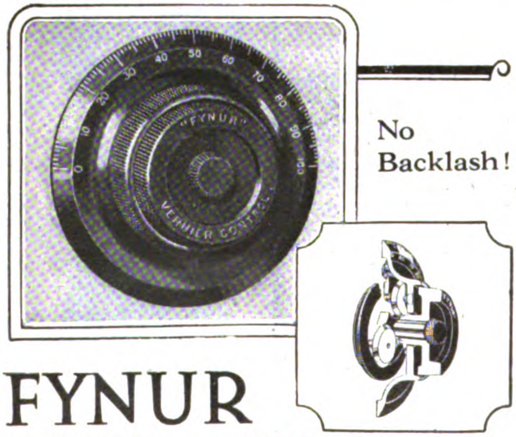
Add 25c. for "E-Z" Fone plug.

CASH WITH ORDER or C. O. D. if ¼ of price is sent with order. Prices F. O. B. Hickory, N. C. Order express shipment, often cheaper than mail and much safer from damage.

FREE WITH EACH CABINET a glued-up stock non-warping ½-inch BASEBOARD.

Free Catalogue.

THE SOUTHERN TOY COMPANY, INC.
Dept. N. HICKORY, NORTH CAROLINA



No Backlash!

FYNUR

VERNIER CONTROL

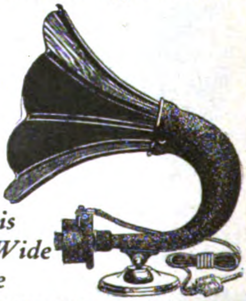
Fynur Dials will separate the low wave length stations and get distant stations clearly and accurately. Dual control, simple and durable in construction. Will fit any ¼ inch shaft. No lost motion. Ask to see one at your dealers or write to manufacturers.

Used in the Laboratory model of the L. C.-26 Receiver, designed by L. M. Cockaday.

AUGUST GOERTZ & CO., INC.
270-286 Morris Ave. Newark, N. J.

AMPLION

For Better Radio Reproduction



Hear this World-Wide Favorite

Creation of Alfred Graham & Co., England, 38 years experienced in producing loud speaking devices. Amplions lead in sales throughout the world. Hear an Amplion—*in comparison!* Six models, including phonograph units, equipped with cords and plugs, $12 up. Write for "Amplion Pedigree."

THE AMPLION CORPORATION OF AMERICA
Suite X, 280 Madison Avenue, New York
Chicago Branch: 27-29 No. Morgan St.
Burndept of Canada, Ltd., Toronto

S-C

4-Tube Receiver

A New Conception of Radio Receivers

Startling in Its Importance

HERE ARE THE EXACT PARTS

1	Belden S-C Wiring Harness	$ 4.00
1	Centralab Resistance# 25 M.S.R.	2.00
1	Polymet .00015 Condenser	.45
1	Polymet .002 Condenser	.40
1	Polymet .005 Condenser	.60
1	Polymet 2 megohm Leak	.25
1	Drilled and Processed Front Panel	4.50
1	Drilled Sub-Panel	2.50
2	S-M# 316 .00035 Condensers	11.50
2	S-M# 515 Coil Sockets	2.00
1	S-M# 110A Coil	2.50
1	S-M# 114A Coil	2.50
4	S-M# 510 Tube Sockets	2.00
1	S-M# 801 Vernier Dial	2.50
1	S-M# 340 .000025 Condenser	1.50
1	Pr. S-M# 540 Mounting Brackets	.70
2	Thordarson R200 Power Transformers	16.00
1	Yaxley# 16K Rheostat	1.35
1	Yaxley# 1 Jack	.50
1	Yaxley# 2 Jack	.60
1	Yaxley# 10 Switch	.50
	Total Price	$58.85
1	Screw Assortment	.15

The features of this receiver embrace everything desirable in a radio set. Laurence M. Cockaday and McMurdo Silver have united their genius to produce this new standard in radio receivers.

A set which can be built in an hour. A complete wiring harness assures success with a screw driver and a pair of pliers.

Complete wavelength range—from the lowest amateur band to the highest wavelength European broadcast station.

Selectivity that brings in 35 stations in New York City, including KFI, while the locals are on—and all on the loud speaker.

True single control which makes operation simple and sure.

Unusually fine tone quality is secured by the use of new Thordarson Power Amplifying Transformers.

Volume for all demands on stations local or distant.

The finished receiver is beautiful. It fits with the appointments of the home.

Send today for the complete parts for this remarkable new receiver. It was designed for YOU!

"The Key To the S-C 4-Tube Receiver" is a booklet containing full information on this set. Price Post Paid 25c

COCKADAY LC-26 BROADCAST RECEIVER

Few sets have given as widespread satisfaction as this famous receiver. The parts exactly as used by the designer, including Tait Brackets and Corbett Cabinet
$79.75

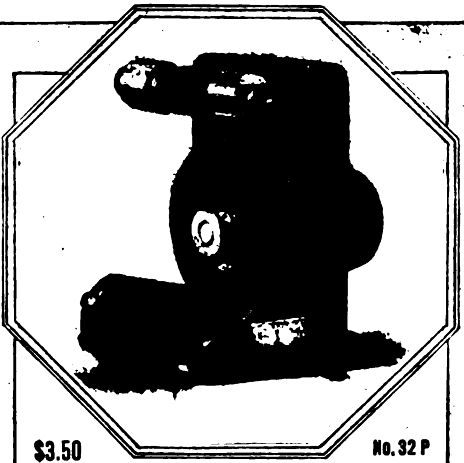
WHOLESALE RETAIL

MORISON
Electrical Supply Co. Inc.

15 East 40th Street, New York City

POWER PACK AMPLIFIER UNIT

Supplies A, B, and C Battery Voltage for any set and includes a distortionless Audio Amplifier. The complete parts as used by the designer and including all wiring data.................. $95.70



$3.50 **No. 32 P**
IN U. S.
(WITHOUT DRY CELL)

Banish Detector Troubles with The Carborundum Stabilizing Detector Unit

By a turn of the knob on the stabilizer you adjust the detector impedance to best suit operating conditions.

You can materially reduce the detector circuit damping, thus giving increased selectivity—sharper tuning.

With this stabilizing unit you get the most efficient rectification—resulting in increased sensitivity—greater volume.

It's a simple device that solves all detector troubles.

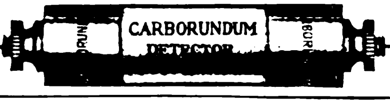
Comes equipped with genuine, fixed Carborundum Detector. An ordinary flash-light cell for booster voltage completes the unit.

You can get the fixed, permanent Carborundum Detector alone for $1.50

YOUR DEALER OR DIRECT
Send for Descriptive Circular Showing Hookups

THE CARBORUNDUM COMPANY
NIAGARA FALLS, N. Y.

New York Chicago Boston Philadelphia
Cleveland · Detroit Cincinnati
Pittsburgh Milwaukee Grand Rapids



Corbett Console for LC-26 Receiver

Five ply mahogany or walnut, with our usual high quality hand rubbed Duo-tone lacquer and varnish finish. Straight or sloping panel front.

The "Corbett Console" is adapted to any of the popular receivers, including McLaughlin, Hammarlund Roberts (Illustrated), G-O and S-C.

WITHOUT HORN **(as illustrated)**	**$40.00**
WITH BUILT IN HORN **(Large Miller hard rubber horn at left of panel with silk backed grill.)**	**54.00**

Shipping charges prepaid

WRITE FOR BOOKLET **showing attractive models for all sizes of radio cabinets, consoles and tables.**

Jobbers & Dealers write for discounts.

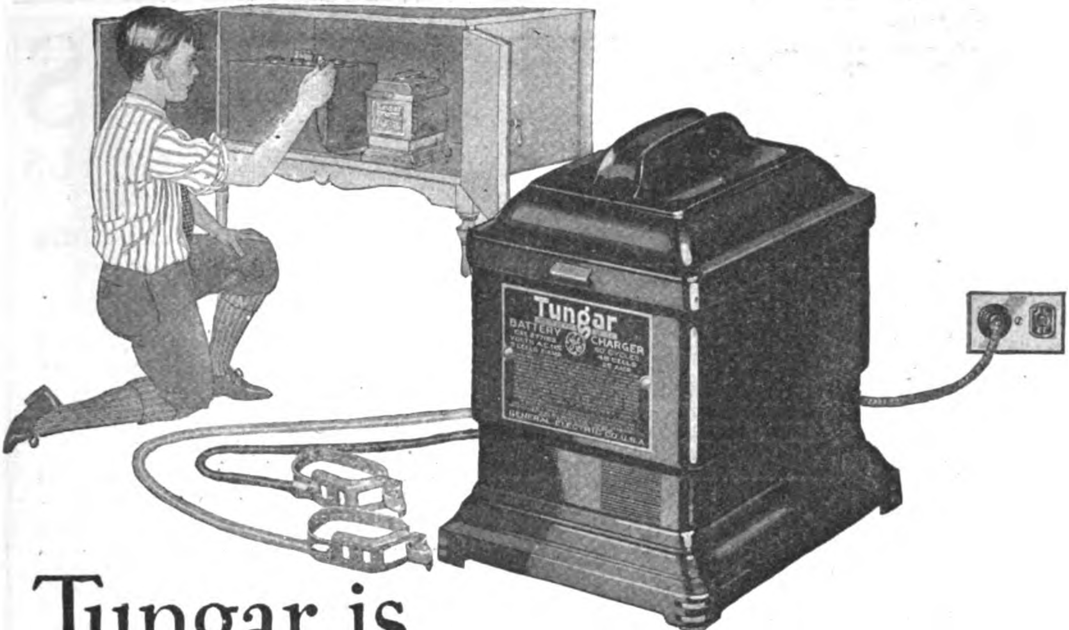
CORBETT CABINET MFG. COMPANY
St. Marys, Pennsylvania

---

screw-machine products —brass

For plugs, jacks, clips, condenser and transformer parts, etc., BRASS assures economy in quantity production. It also gives the right electrical conductivity and the mechanical accuracy essential to proper operation of radio sets and parts.

COPPER & BRASS
RESEARCH ASSOCIATION
25 Broadway, New York



Tungar is the easy-to-use charger

Anyone can clip a Tungar to a battery and plug it in on the house current. That's all there is to it.

Attach a Tungar at night—and have snappy batteries in the morning. It will not blow out Radiotrons.

It needs little attention. Only a dime's worth of current consumed for a charge. No wonder "Tungar" is fast becoming the word for battery charger.

Tungar is the original bulb charger. It is a G-E product developed in the Research Laboratories of General Electric

The new Tungar charges 2, 4 and 6 volt "A" batteries, 24 to 96 volt "B" batteries, in series: and auto batteries, too. No extra attachments needed.

East of Rockies

Two ampere size $18.00
Five ampere size $28.00

60 cycles - 110 volts

Merchandise Department
General Electric Company
Bridgeport, Connecticut

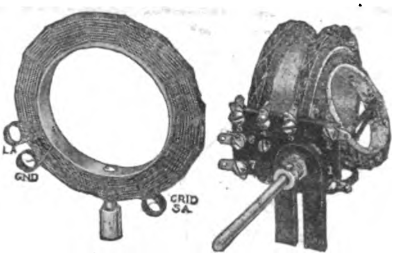
Tungar

REG. U.S. PAT OFF.

BATTERY CHARGER

Tungar—a registered trademark—is found only on the genuine. Look for it on the name plate.

GENERAL ELECTRIC



Sickles Coil Set No. 24 for Browning-Drake Circuit. **Price $7.50.**

COIL PRICES

No. 18A	Roberts Circuit	$8.00 set
Na. 24	Browning-Drake	7.50 set
No. 20	Craig Circuits	4.50 set
No. 19	Acme Reflex	4.50 set
No. 8	Knockout Reflex	4.00 set
No. 21	Hoyt Circuit	10.00 set
No. 25	Aristocrat Circuit	8.00 set

SICKLES

DIAMOND-WEAVE COILS

(Trade Mark registered Aug. 4, 1925)

For Browning-Drake, Roberts, Craig, Aristocrat and Hoyt Circuits

(Patented Aug. 21, 1923)

The Sickles No. 18A coil combination is designed specifically for the Roberts Reflex and other reflex circuits using neutralized radio frequency amplification, combined with regeneration controlled by a movable ticker.

The No. 25 coil combination is built for the Aristocrat Circuit, and it will also work admirably in all of the universal circuits using tuned radio frequency amplification, neutralized by the Rice Method and combined with regeneration.

Send for descriptive catalog

The F. W. Sickles Co.
134 Union Street
SPRINGFIELD, MASS.

FOR CLEAR, QUIET "B" POWER

$2.75

RADIO Storage "B" Battery

12 Cells 24 Volts *Lasts Indefinitely—Pays for Itself*

Economy and performance unheard of before. Recharged at a negligible cost. Delivers unfailing power that is clear, pure and **quiet.** Approved and listed as Standard by leading Radio Authorities, including Pop. Radio Laboratories, Pop. Sci. Inst. Standards, Radio News Lab., Lefax, Inc., and other important institutions. Equipped with *Solid Rubber Case*, an insurance against acid and leakage. Extra heavy glass jars. Heavy rugged plates. Order yours today!

SEND NO MONEY Just state number of batteries wanted and we will ship day order is received. **Extra offer:** 4 batteries in series (96 volts), $10.50. Pay expressman after examining batteries. **5 per cent discount for cash** with order. Mail your order **now!**

WORLD BATTERY COMPANY
1219 So. Wabash Ave., Dept. 77 Chicago, Ill.

Makers of the Famous World Radio "A" Storage Battery
Prices: *6-volt, 100 Amp. $11.25; 120 Amp. $13.25; 140 Amp. $14.00.*
All equipped with Solid Rubber Case.

World
STORAGE BATTERIES

Set your Radio Dials at 210 meters for the new 1000 watt World Storage Battery Station, WSBC, Chicago. Watch for announcements.

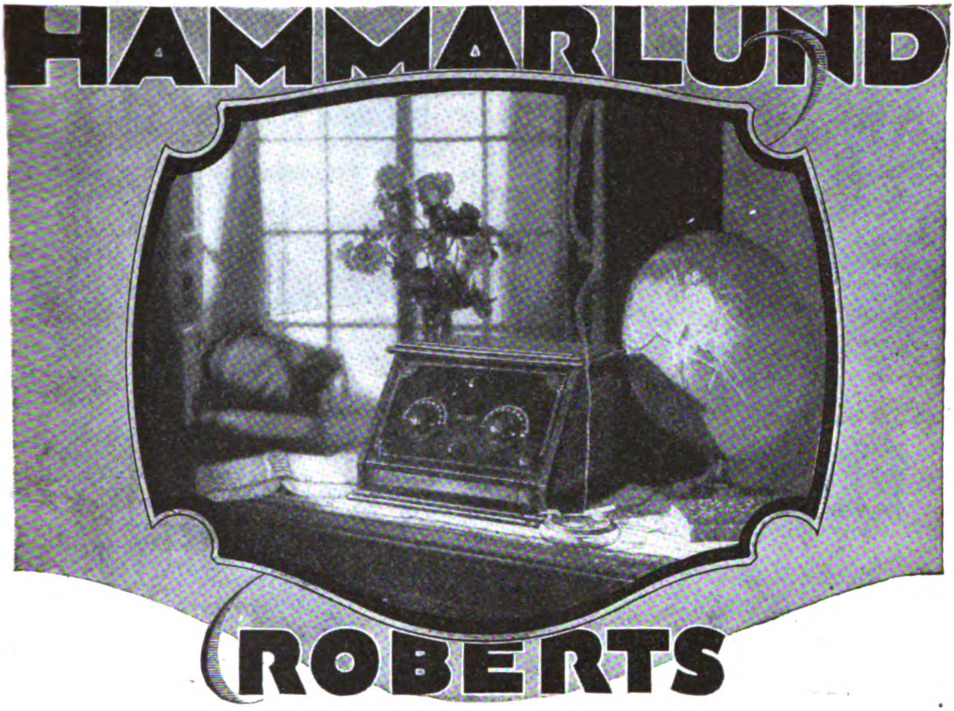
KDKA ⚡ WEAF ⚡ WGN ⚡ WJS ⚡ KHJ ⚡ KGO ⚡ KFAF ⚡ WJY ⚡ KOP

More Profits for the PROFESSIONAL Set Builder

WE have an unusually interesting proposition to make to the man who is now building (*or has the ability to build*) radio receiving sets for resale.

This is a real opportunity. Write to-day for full information.

Gearhart-Schlueter Radio Corp.
714 Voorman Ave.
Fresno, California



FOR a long time to come, there will not be evolved a more efficient circuit than that in the new Hammarlund-Roberts Receiver.

Ten leading radio engineers devised it as their composite ideal. The result is a receiver, operating on only five tubes, which possesses the sensitivity of a standard eight-tube receiver, plus a high degree of selectivity which minimizes interference:

Tuning is simplicity itself. The volume and tone are exceptional, the receiver being designed to operate on the cone type of speaker.

And best of all, you can construct it yourself, from the finest parts known to radio, with results worthy of any professional builder.

The cost, $60.80 (cabinet extra) is only about one-third of the price of a factory-built receiver of similar quality.

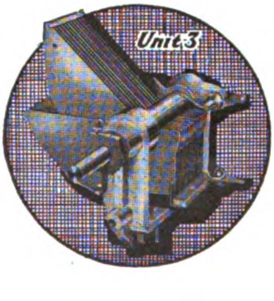
Your dealer sells the famous Hammarlund parts for this receiver and can supply you with all the other parts specified in the "How to Build" book, which will be mailed on receipt of 25 cents.

For Better Radio
Hammarlund
PRECISION
PRODUCTS

HAMMARLUND MFG. CO.

**424-438 W. 33d St.
New York**

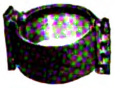
UNIT 2. — "Hammarlund, Jr." The Precision Midget Condenser.
UNIT 3. — The New Hammarlund Straight-line frequency Condenser.
UNIT 4. — The New Hammarlund Low-Loss, Space-Wound Coils.

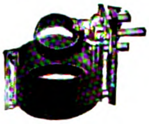


FOUNDATION UNIT

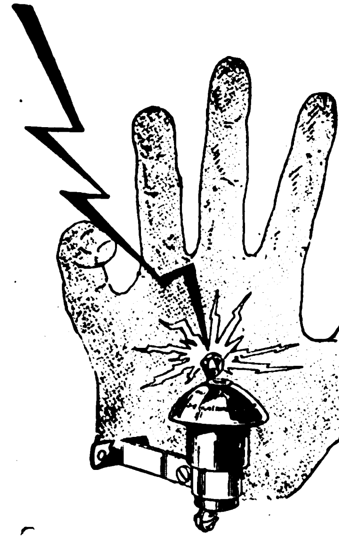
The Foundation Unit contains all *special* parts needed to build the Hammarlund-Roberts Receiver, including drilled and engraved panels, brackets, wire, screws, etc. $7.90, at your dealers.

UNIT 4





UNIT 4



It says

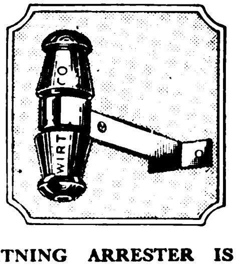
"Stop"

and lightning won't harm your set

The National Board of Fire Underwriters specify that an approved Radio Lightning Arrester *must* be used with all out-door aerial installations.

Protection is easy. Insure your insurance and save your set with a **WIRT LIGHTNING ARRESTER** (listed as standard by the Underwriters Laboratories). The cost is a trifle.

THE WIRT LIGHTNING ARRESTER is an approved air gap type, made of bakelite giving ample insulation, with brass terminals moulded in bakelite, far enough apart so that there is no leakage. A "petticoat" of bakelite shields the arrester from water and dust. Handsome and rigid. Lasts a lifetime. Easy to install. Full directions on box.



When you install your **WIRT LIGHTNING ARRESTER**, get a **WIRT INSULATOR** and prevent leakage along your lead-in wires. It keeps the wire at the proper distance, provides perfect insulation, and prevents wear and tear on the wire by preventing sagging and swaying.

THE WIRT LIGHTNING ARRESTER IS LISTED AS STANDARD BY THE UNDERWRITERS LABORATORIES.

WIRT LIGHTNING ARRESTER	$1.00
WIRT INSULATOR	.35

Sold by leading Radio dealers

WIRT COMPANY

PHILADELPHIA PENNSYLVANIA

Makers of Dim-A-Lite

To-day -in every good set!

100% Value From Each Tube

What's the use of buying good tubes if you don't get their full value? Individual, automatic tube control is the answer. Amperite alone gives it. That's why it is specified in every popular construction set. Offers precision regulation—automatically. No hand rheostats to regulate. Eliminates all errors of human judgment. A special type for every style and strength of tube. Price $1.10.

Write for free hook-ups

Radiall Company

Dept. P.R.4, 50 Franklin St., N. Y. City

AMPERITE

REG. U.S. PAT. OFF.

The **"SELF-ADJUSTING"** *Rheostat*

QUALITY DONGAN PRODUCTS

Addressed to

Forward-thinking but Skeptical Set Manufacturers

Gentlemen:

It is true that to sell your sets this coming season you must build in a real B-Eliminator. Where is there one? You ask.

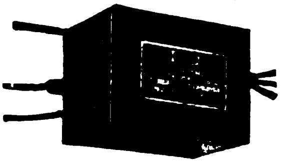
We can furnish you with the most important parts — Transformers and Chokes, Unmounted—and show you how to build your own B-Eliminators.

Dongan has built transformers for 15 years. Our products are endorsed by the manufacturer of Raytheon Tubes and the laboratories of the prominent radio publications. Our reputation is high—and precious.

Sincerely

DONGAN ELECTRIC MFG. CO.

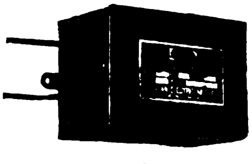
2983-3001 Franklin St., Detroit, Mich.



TRANSFORMERS

No. 509 Full Wave

$7.00 List



CHOKES

514 20 henry

$5.00 List

Also Transformers and Chokes for R.C.A. and Cunningham Tubes

RAYTHEON TUBES

$6.00 list

Fans

If your dealer cannot supply you send money order direct.

TRANSFORMERS of MERIT for FIFTEEN YEARS

J.B. Ferguson INCORPORATED

The Gold Standard of Radio Receivers

As THE "FORTY-NINERS" washed out for the hidden particles of gold, so, today, the wise buyer—sifting through a confusion of extravagant claims and choosing on performance alone—finds Ferguson, "The Gold Standard of Radio Receivers." For each precision-built Ferguson, tested and re-checked by master craftsmen, wins in the acid test of comparison.

Readily piercing through the maze of local broadcasters, the Ferguson unfailingly finds the more remote sections. Its three stages of *Matched Audio* give ample volume so that you may not only *hear* but *enjoy* their programs. Its life-like reproduction is true as gold.

One Tuning Control Calibrated in Meters!

Select your program, turn up its wavelength and in comes your station. In accomplishing this feat in radio design, there has not been the slightest sacrifice in electrical efficiency.

Arrange with the nearest Authorized Ferguson Dealer for a demonstration in your own home, or write us.

J. B. FERGUSON, Inc.
41 East 42d Street
NEW YORK, N. Y.

The single tuning knob revolves the shaft by means of a split gear that eliminates all backlash. A pivot-bearing gives this control its velvet-smooth ease. The Receiver is mounted upon a rigid aluminum chassis.

CABINET MODEL EIGHT
A Six-tube Tuned r. f. Receiver, $226

A. RADIO PHAN

ANYWHERES, U. S. A.

Mr. Mike Rofone.
Dear Mike:

Just wanted to tell you how wonderful your broadcasting sounded last night.

I heard the program on an Arborphone Set using a Timbretone speaker and never before realized how wonderful Radio really was.

I have since found out that the Timbretone Speaker is one of the few on the market that is really built to reproduce music and speech.

Found it was built to bring out the overtones and harmonics of music with the same fidelity that appeals to lovers of music who really appreciate real "Quality." Being all wood it has a "mellow" tone, unequaled.

I paid thirty dollars for it but, gosh, I have a good set so couldn't afford to spoil it all with a cheaper speaker.

Will write you again next month. Till then,

Sincerely yours,

Tim Bretone

SEE THAT SCREW

A screw driver adjusts an X-L in crowded places.

X-L VARIODENSER

Results in easier tuning, **more distance,** volume and clarity -- **greater stability.**

Indorsed by leading radio authorities

Model "N" A slight turn obtains correct tube oscillation on all tuned radio frequency circuits. Neutrodyne, Roberts two tube, Browning-Drake, McMurdo Silver's Knockout, etc., capacity range 1.8 to 20 micro-micro farads. Price $1.00.

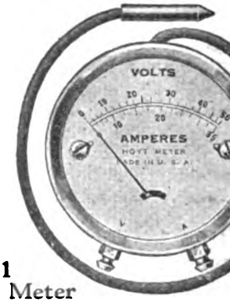
Model "G" with grid clips obtains the proper grid capacity on Cockaday circuits, filter and intermediate frequency tuning in heterodyne and positive grid bias in all sets. Capacity range .00016 to .00055 and .0003 to .001 micro farads. Price $1.50.

X-L PUSH POST

Push it down with your thumb, insert wire, remove pressure and wire is firmly held. Releases instantly. Price 15c.

X-L Radio Laboratories
2422 LINCOLN AVE.,
CHICAGO, ILL.

Hoyt Pocket Meters



Hoyt Type 31 Pocket Meter

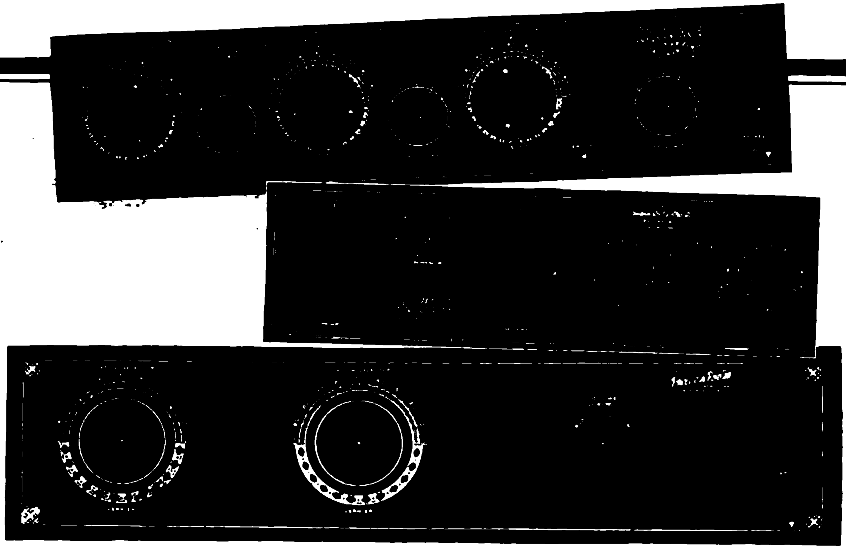
The indispensable pocket instrument for Dealers and Radio Owners for checking the condition of A and B batteries. Reads up to 50 volts or 35 amperes. All scales are *hand-calibrated,* resistance of meter is unusually high for this type, accuracy does not vary in extreme heat or cold.

Finished in polished nickel, of small size, convenient for handling.

Price, complete with lead
$3.00

BURTON-ROGERS CO.
26 Brighton Ave. Boston, Mass.
National Distributors

HOYT makes a complete line of Radio Meters. Send for booklet "HOYT Meters for Radio."



Veri Chrome and Formica Provide the Finest Radio Panel

The great variety and beauty of the decorations for radio panels that are possible with Veri Chrome and the remarkable permanence of a Formica panel so decorated, have made sets with Veri Chromed panels very popular.

You will find Veri Chromed panels—some of them decorated with the work of the leading artists—on many of the finest sets this year.

To give kit buyers who assemble their own sets a chance to purchase decorated panels, we have prepared panels for some of the better known kits.

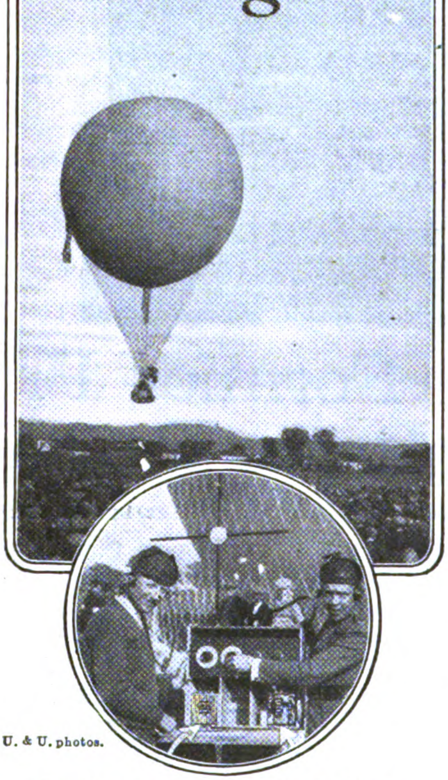
Bremer Tully No. 1, Bremer Tully Counterphase, Bremer Tully Nameless, two sizes of Best's Superheterodyne put out by Remler; the Browning Drake receiver offered by the National Company, The Marco Browning Drake and the Radio Broadcast Universal Receiver are kits for which Veri Chromed panels are now available. See your dealer or jobber or write us direct. Panels of all standard sizes are packed in neat individual envelopes and sold by dealers to home set builders.

Write for booklet *"What Formica Is"*

THE FORMICA INSULATION COMPANY
4641 Spring Grove Avenue, Cincinnati, Ohio

FORMICA
Made from Anhydrous Bakelite Resins
SHEETS TUBES RODS

BURGESS
RADIO BATTERIES
Win Again



U. & U. photos.

The illustration pictures the take-off of the winning flight and the insert is the radio equipment carried. (Burgess 'A,' 'B' and 'C' Batteries furnished the electrical energy to operate the set.)

When the Goodyear III won the right to represent the United States at Belgium, Burgess Radio Batteries supplied the electrical energy for the operation of the balloon's radio equipment.

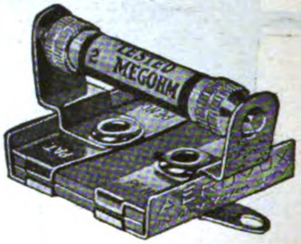
Almost every day from some where in the world news comes to us of new Burgess adventures.

And that Burgess Batteries have contributed their bit in so many interesting events of sport, commerce and science reflects the esteem in which they are held.

"Ask Any Radio Engineer"

Your own radio dealer down the street sells Burgess Batteries. He probably sells the famous Burgess Flashlights, too.

BURGESS BATTERY COMPANY
GENERAL SALES OFFICE: CHICAGO
Canadian Factories and Offices:
Niagara Falls and Winnipeg



AEROVOX
FIXED CONDENSERS
"Built to be Better"

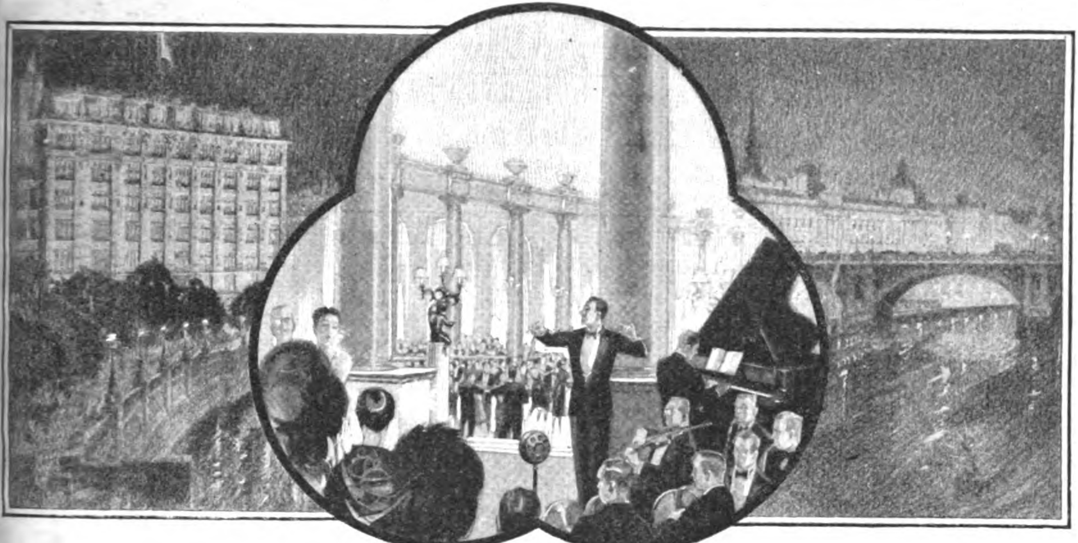
AEROVOX WIRELESS CORPORATION
489-491-493 Broome St., New York City
Branch Offices:
Chicago, Ill.
53 W. Jackson Blvd.
Cincinnati, Ohio
304 Palace Theatre Bldg.
Boston Mass.
104 Portland St.
Los Angeles, Cal.
324 N. San Pedro St.

-it's in the Tube

Your receiving set can be no better than its tubes. CECO Tubes give maximum results in clarity of tone, rich volume and long life.
Our charted tests (results confirmed by laboratories of national reputation) PROVE CECO TUBES SUPERIORITY—as detectors, as amplifiers.
Buy CeCo Tubes whether your set takes one tube or eight. Now ready! CeCo Tubes with new type Long PRONG BASES. Also, power amplifier tubes, E (Dry Cell Type), F (Storage Battery), for last stage of Audio Frequency. Ask your radio dealer.

C. E. Mfg. Co., Inc.
702 Eddy St., Providence, R. I.

CECO
TUBES



"This is Station 2-L.O. London—12 Midnight"

When listeners-in on this side of the Atlantic first heard the voice of the British announcer, and then a program of music from the famous Savoy in London, they experienced one of the real thrills of radio.

To get everything that is on the air—the faint signals as well as the strong ones—effective insulation of all radio parts is a prime essential. The best way to make sure that a radio set or parts are well insulated, is to buy those in which Bakelite is used.

Bakelite is used by 95% of radio set and parts manufacturers. It is the standard material for front and base panels, dials, knobs, tube sockets and bases, fixed and variable condensers, rheostats, plugs and other radio accessories and parts. Write us for a copy of Booklet, No. 28, "Bakelite in Radio"—it's a helpful guide in buying radio equipment.

BAKELITE CORPORATION
247 Park Avenue, New York, N.Y
Chicago Office: 636 West 22nd St
BAKELITE CORP. OF CANADA Ltd
163 Dufferin St., Toronto, Ontario, Can

BAKELITE

REGISTERED U. S. PAT. OFF.

THE MATERIAL OF A THOUSAND USES

"The registered Trade Mark and Symbol shown above may be used only on products made from materials manufactured by Bakelite Corporation. Under the capital "B" is the numerical sign for infinity, or unlimited quantity. It symbolizes the infinite number of present and future uses of Bakelite Corporation's products."

First in the Field Specializing in Cockaday Kits

S. HAMMER RADIO CO.,

303 Atkins Ave.
Brooklyn, New York

Cockaday Sets Now Made Easier to Build by Our New "Ready-to-Wire" Plan

50% of Your Time, Work and Worry SAVED!

All you need do is to connect bus-bar according to diagram, solder and your set is finished. These Kits are sent to you completely mounted, and assembled on a Veneered Mahogany baseboard and genuine bakelite panel, drilled and engraved. Genuine parts used as listed below; exactly as used in Mr. Cockaday's Laboratory Model. COMPARE OUR OFFER!

"POWER UNIT"

These are the exact parts, used in building the Laboratory Model of the "POWER UNIT"

1 Amertran power transformer, type PF-52..	$18.00
1 Amertran De Luxe A. F. transformer for second stage......	10.00
3 Amerchokes, type 854.	18.00
2 Dubilier filter condensers, type 769, 2 mfd. (working voltage 400 volts D. C.)........	7.00
2 Dubilier filter condensers, type 770, 4 mfd. (working voltage 400 volts D. C.).	14.00
4 Dubilier filter condensers, type 766, 2 mfd. (working voltage 160 volts D. C.).	8.00
1 Aerovox Craig resister, type 980............	4.00
1 Bradleyohm No. 25—25,000 to 250,000 -ohms..............	$2.00
2 Pacent single-circuit jacks, No. 61.......	1.00
2 Benjamin push - type sockets, No. 9040...	1.50
Bakelite sub-base, 7x21x¼ inch Drilled........	4.45
Bakelite binding-post strip, 7x1x¼ inch...	.35
Angle brass reinforcement strips for sub-base pr.	.75
Angle brass for holding binding post strip, pr.	.10
Brass brackets for mounting resistor unit M, pr.	.35
Brass strip for mounting filter condensers....	.35

COMPLETE KIT **$89.85**

The Following UNASSEMBLED and READY-TO-WIRE KITS IN STOCK

S-C RECEIVER Raytheon Plate Supply Unit; McLaughlin Single Control Superheterodyne; Hammarlund Roberts Kits.

Cockaday's New LC-26 Receiver

1 General Radio Variometer type 269 with rheostat knob..................	$5.30
1 General Radio Rheostat type 214-a, 7 ohms, with rheostat knob............	2.25
1 Precision Octaform coil set	5.50
1 Amsco Double Unit Condenser No. 1814........	6.25
1 Micamold fixed Condenser .00015 mfd.............	.35
1 Micamold fixed Condenser .00025 mfd............	.35
2 Daven resisto-couplers (new type)..................	3.00
1 Amertran DeLuxe transformer, first stage..........	10.00
Bradleyleak ¼ to 10 meg.	1.85
3 Bradleyunits, ¼ megohm...	$2.25
1 Bradleyunit ¼ megohm....	.75
3 Amperites No. 1a..........	3.30
1 Amperite No. 112.........	1.10
5 Benjamin standard "Cle-ra-tone" sockets..........	5.00
1 Carter single-circuit jack No. 101................	.70
2 Carter Jack switches No. 2	2.00
8 Eby binding posts.........	1.20
1 Fynur vernier control knob and dial.................	3.50
1 Universal decorated panel, 8 x 22 inches...........	7.50
4 Small brass brackets.....	
2 Bakelite Connection Blocks 1 x 2 plus 1 x 9.....	
2 Large Brass Brackets....	.35

READY-TO-WIRE KIT, PRICE, . $62.50

WIRED COMPLETE **In Genuine Mahogany Cabinet $77.00**

UNASSEMBLED KITS IN STOCK

BEST 5 TUBE SUPERHETERODYNE

Send for Free Radio Catalog and Complete Information about our Parts and Kits.

WRITE FOR BOOKLET about these Parts and Kits

Transportation Prepaid. One-third must accompany all C. O. D. orders. Not insured unless insurance charges included

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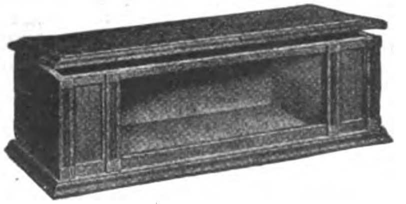
Premier B Battery Cabinet



Our Premier B Battery Cabinet is a beautiful piece of furniture. The B battery compartment will take any type B battery. The space of each B battery compartment is 4½" wide, 8½" high and 10" deep.

No.	For Panel	Deep	Genuine Walnut
718-10	7 x 18	10"	$18.50
721-10	7 x 21	10"	19.00
724-10	7 x 24	10"	19.50
726-10	7 x 26	10"	20.00
728-10	7 x 28	10"	21.00
730-10	7 x 30	10"	22.00

F.O.B. Waukesha, Wis.

The tops of these cabinets are figured walnut, the ends and B battery panels are select walnut, all 5 ply veneer. The bases are built up of massive molding. Nickel plated piano hinges and lid holders. The material and finish in these cabinets will equal the best furniture obtainable.

WE MAKE 9 STYLES OF CABINETS FOR 14 SIZES OF PANELS. Send for our 1925-26 line of cabinets at "Factory to User" prices.

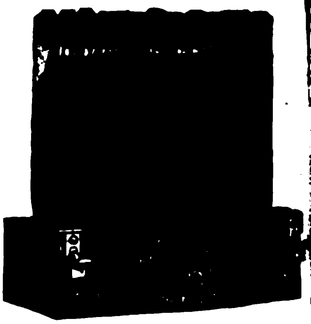
Utility Cabinet Company

Phone 721 **Waukesha, Wisconsin**

22½ Volt un-acid everlasting rechargeable "B" Storage Battery

$2.95

includes chemical



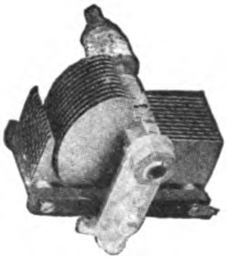
45 volts $5.25, 90 volts $10.00, 112½ volts $12.50, 135 volts $14.75, 157½ volts $16.80. Truly the biggest buy today. Easily charged on any current including 32 volt systems. Any special detector plate voltage had. Tested and approved by leading authorities such as POPULAR RADIO laboratories. Over 3 years sold on a non-red tape 30 day trial offer with complete refund if not thoroughly satisfied. Further guaranteed 2 years. Knock-down kits at greater savings. Complete "Hawley" "B" Battery charger $2.75. Sample cell 35c. Order direct—send no money—simply pay the expressman cost on delivery. Or write for my free literature, testimonials and guarantee. Same day shipments.

B. HAWLEY SMITH, 315 Washington Ave., Danbury, Conn.

SM PARTS

THE SC RECEIVER

In this new, single-control, all-wave, 4-tube receiver, designed by eight eminent, engineering staffs, SM PARTS were used wherever possible. Their unquestionable excellence and dependability made SM Parts the logical selection for this advanced receiver. That is why in almost every successful receiver design of past and present seasons you will invariably find SM Products—depended upon, and dependable.

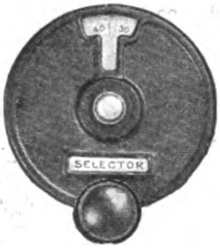


Type 316 Condenser, .00035 Mfd. for single or gang control. Brass plates, die cast frame. Price, $5.75.

SM THORDARSON RAYTHEON B-ELIMINATOR

The SM Type 650 Kit includes Thordarson Transformer, choke, Tube Condensers, genuine Raytheon Tube, Bradleyohms and all necessary parts....................................$34

This Eliminator will deliver from 20 to 200 volts at three different adjustable voltages with maximum current of 50 milliamperes—more than enough for the largest receiver. Send for Assembly Instructions by Mc Murdo Silver..........................10c



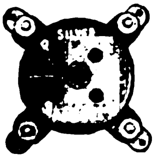
Type 801 Universal Vernier Dial, Ratio 14.5:1. Fits any standard condenser right or left, 180 or 360° movement. Price, $2.50.

See SM Products at Your Dealers
or Write for Circulars

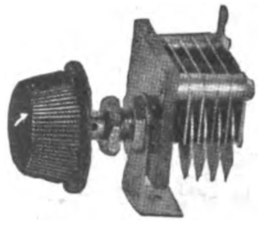
Silver-Marshall, Inc.

112 S. Wabash Ave., Chicago.

Interchangeable Coils for any wavelength. Standard Sizes, $2.50. Type 515 Coil Socket, $1.00.

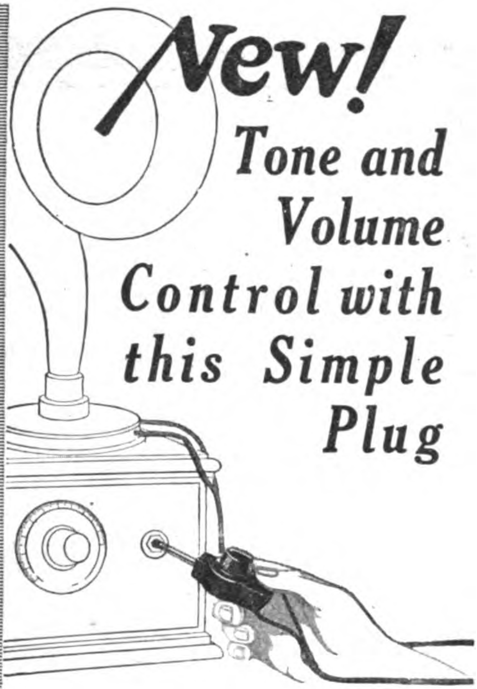


Type 510 All-Bakelite Socket for UX Tubes, 50c.



Type 340 Compensating Condenser, .000025 Mfd. with knob, $1.50.

New! Tone and Volume Control with this Simple Plug



GIVES any degree of tone volume from a whisper to maximum by simply turning the small knob on plug. Static interference is reduced; programs come in clear and true with just the volume you most enjoy.

New high-priced sets feature tone control as their greatest improvement. You can have this new feature in your old set by attaching a *Centralab Modulator Plug* in place of the old phone plug. Only takes a minute to make the change. *Order from your dealer, or mailed direct. Price* $2.50.

Centralab Control Used in New S-C Set

The new S-C Circuit includes the Centralab Radiohm for oscillation control because it was found to do the job in first class order. It holds that sensitive regenerative position immediately preceding the oscillation point without distortion or loss of selectivity—provides smooth, noiseless variation. That is why 66 manufacturers of sets are using Centralab as standard units in 1926 models. At *your dealer's —or mailed direct. Price*: $2.00. Write for literature describing Centralab controls.

Central Radio Laboratories
17 Keefe Ave., Milwaukee, Wis.

Centralab CRL

FREE!

12-Cell—24 Volt Storage 'B' Battery

Positively given free with each purchase of a WORLD "A" Storage Battery. You must send this ad. with your order. WORLD Batteries are famous for their guaranteed quality and service. Backed by years of successful manufacture and thousands of satisfied users. Equipped with *Solid Rubber Case*, an insurance against acid and leakage. You save 50 per cent and get a

2-Year Guarantee Bond in Writing

WORLD Battery owners "tell their friends." That's our best proof of performance. Send your order in today.

Solid Rubber Case Radio Batteries

6-Volt, 100-Amperes	$11.25
6-Volt, 120-Amperes	13.25
6-Volt, 140-Amperes	14.00

Solid Rubber Case Auto Batteries

6-Volt, 11-Plate	$11.25
6-Volt, 13-Plate	13.25
12-Volt, 7-Plate	16.00

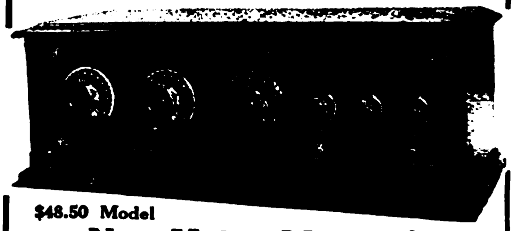
SEND NO MONEY Just state battery wanted and we will ship day order is received, by Express C. O. D., subject to your examination on arrival. **FREE "B"** Battery included. **Extra Offer:** 5 per cent discount for cash in full with order. Buy now and get a guaranteed battery at 50 per cent saving to you.

Approved and Listed as Standard by Leading Authorities including Radio News Laboratories; Popular Science Institute of Standards, Popular Radio Laboratories, Radio Broadcast Laboratories, Radio in the Home, and Lefax, Inc.

WORLD BATTERY COMPANY
1219 So. Wabash Ave., Dept. 3 CHICAGO, ILL.

World STORAGE BATTERIES For AUTO and RADIO

GET—LONDON



$48.50 Model

New Hetro-Magnetic

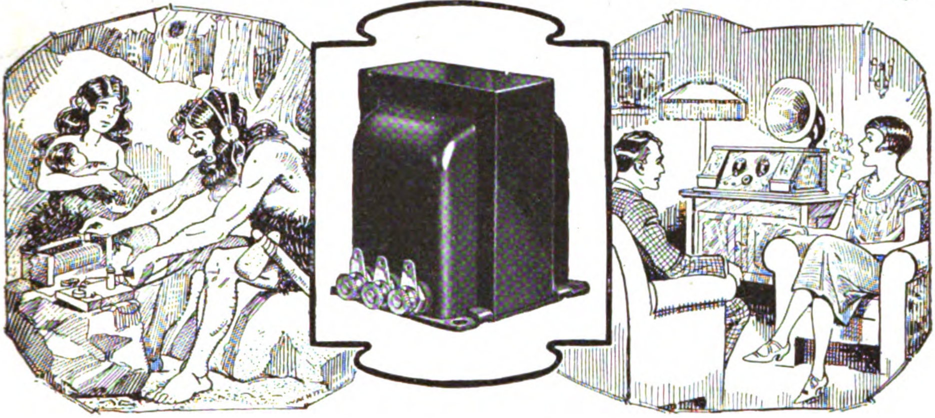
Hundreds of POPULAR RADIO readers were quick to take advantage of the remarkable low price for the above receiver—thoroughly tested by the POPULAR RADIO laboratory and now recognized as one of the most powerful radio receivers. New magnetic coils make five tubes give the volume, distance and selectivity of eight.

Large circular describing set and giving complete description of its novel features sent on request.

Above set in 30" walnut cabinet	**$48.50**
Set less cabinet	**39.50**
Complete knock-down kit	**25.00**

MERCURY ELECTRIC CORPORATION
2032 Grand Ave., New York, N. Y.

Modernize Your Radio Set!



THORDARSON Autoformer

Trade-Mark Registered

All Frequency Amplifier

Write for free descriptive circular

Price $5.00

Are you still using primitive methods of amplification? Why not make your receiver an up-to-date model by installing Autoformer amplification—the ultimate in reproductive equipment?

The Autoformer, a step up impedance amplifier, reproduces with full volume those bass notes lost in ordinary transformer amplifiers.

The Autoformer provides the unrestrained flow of distortionless music. It records everything from the slightest shading to the greatest extreme of volume, intensity and timbre.

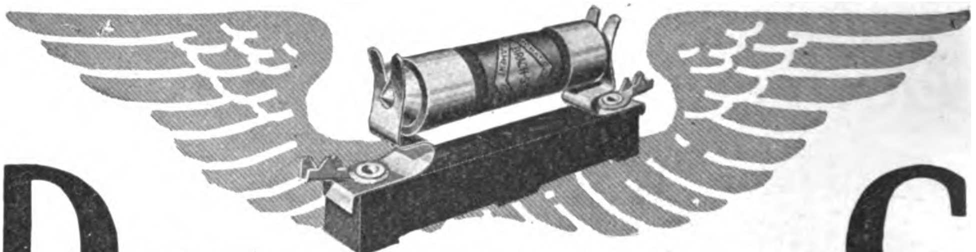
Better volume control.
More volume on distant stations.
Full bass note amplification.
Greater clarity on all signals.

OTHER THORDARSON TRANSFORMERS

R-200 Amplifying Transformer
Standard Amplifying Transformer
Power Amplifying Transformer
Interstage Power Transformer

B-Eliminator Transformer
B-Eliminator Chokes
Battery Charging Transformers
Transmission Equipment

THORDARSON ELECTRIC MANUFACTURING CO.
Transformer specialists since 1895
WORLD'S OLDEST AND LARGEST EXCLUSIVE TRANSFORMER MAKERS
Chicago, U.S.A.



DOMINATING ITS FIELD

BECAUSE OF SUPERIOR MERIT

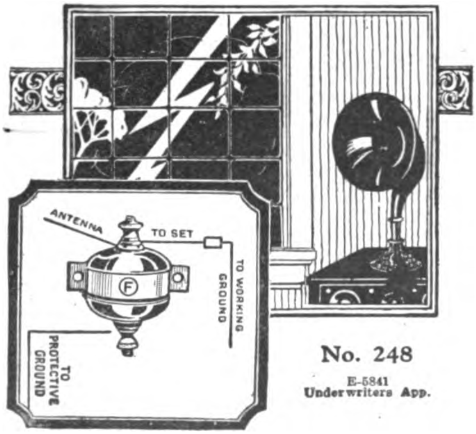
BRACH-STAT

– THE AUTOMATIC FILAMENT CONTROL

We are prepared at any time to prove Brach-Stat superiority over any other form of filament control ballast.

The life of a radio tube is materially shortened when even slightly overloaded. Leading set makers and discriminating engineers insist upon Brach-Stats because they positively prevent overloading and provide perfect filament control.

L. S. BRACH MFG. CO., NEWARK, N. J.



No. 248
E-5841
Underwriters App.

"Little Joe"

Lightning Arrester

Especially designed for Radio Work. Made of Porcelain, small, neat, rugged and serviceable. Can be suspended on antenna or fastened to wall.

Ask Your Dealer

M'f'd by **CIRCLE F MFG. CO.**
Trenton, New Jersey

STATIC????

Or have the "B" batteries run down again? Why not eliminate this constant expense with our THORDARSON-RAYTHEON eliminator built to POPULAR RADIO specifications (See November 1925 issue) for only $39.00. Extra voltage taps at slight additional cost. Our unit delivers 160 volts at 32 milliamperes.

We KNOW the LC-26; and by the way, did you see our last month's advertisement?

***The* METROPOLITAN LABORATORIES**
86-88 West Broadway, New York City
" The Best is the Cheapest"

Send for this New Hookup

S-C

No choicer group of radio products has ever been embodied in a single radio receiver. Not only are these manufacturers nationally known and accepted as the leaders in radio design and construction, but they have developed for the S-C receiver many new features which will create a new standard in reception throughout the radio world

Represented Manufacturers:

Belden Mfg. Co.
S-C Wiring Harness

Central Radio Laboratories
Centralab Resistance

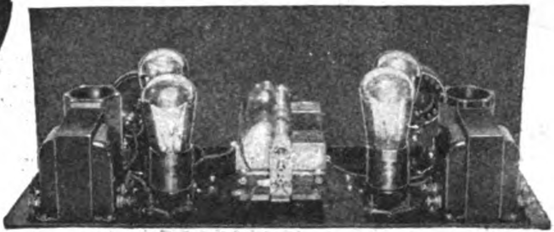
Polymet Mfg. Corporation
Fixed Condensers, Leak and Leak Clips

Poster & Co.
Drilled and Processed Front Panel and Drilled Sub-Panel

Silver-Marshall, Inc.
Variable Condensers, Coil Sockets, Coils, Tube Sockets, Vernier Dial, Mounting Brackets

Thordarson Electric Mfg. Co.
R-200 Power Transformers

Yaxley Mfg. Co.
Rheostat, Jacks, Switch



Four Tube Receiver

The outstanding receiver development of the season, combining the genius of two of the most distinguished radio engineers. A receiver for the home builder that will represent for several seasons greater value than any other design available.

Here is a receiver that will represent to the home set builder a greater dollar for dollar value for years to come than any other design now available.

Startling New Features

SINGLE CONTROL—But one tuning or station selector control.
SELECTIVITY—In a residential district of New York City, within a few hundred yards of powerful stations, thirty-five stations were heard between 9 and 10 p. m. on the loud-speaker. KFI, in Los Angeles was heard with ample volume to fill two rooms.
QUALITY—Two new-type Thordarson power amplifying transformers possessing a substantially flat frequency characteristic over the range of 40 to 6,000 cycles, give a superior quality of distortionless reproduction.

VOLUME—Exceeds that of other four-tube receivers, and equals that obtainable from standard five and six-tube receivers.

UNLIMITED WAVE LENGTH RANGE, through the use of interchangeable coils.

WIRING AND ASSEMBLY—All wiring is carried in a special harness. Since each wire is exactly the right length, and has a special color, it is impossible to go wrong in wiring. Over-all design, rugged and solid. Adapted to practically any standard cabinet, any standard tube, any battery or eliminator source of supply, outdoor antenna or loop. While the parts are the best that the leading laboratories of the country afford, the set can be built at an extremely low cost. Full description of the receiver was published in the March issue of Popular Radio.

Get the hand book at your nearest Radio Dealer or clip the coupon and send with 25 cents TO-DAY. Address

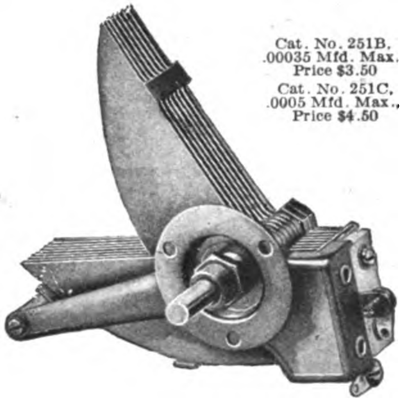
The S. C. Merchandising Company
64 E. Jackson Blvd.
Chicago

The S-C Merchandising Company
64 E. Jackson Blvd., Chicago

Gentlemen: Please find enclosed 25c. for which send me hand book of new S-C Receiver.

NAME ______________________

ADDRESS ______________________



Cat. No. 251B,
.00035 Mfd. Max.,
Price $3.50
Cat. No. 251C,
.0005 Mfd. Max.,
Price $4.50

This Condenser Assures Quick Certain Tuning!

THE PACENT TRUE STRAIGHT LINE FREQUENCY CONDENSER is the result of 18 months' intensive research and experiments on the part of Pacent Engineers to perfect a precision instrument to really solve the radio fan's problem of quick, certain tuning.

The Pacent Condenser—by uniformly spacing stations round the dial according to frequency—will amazingly improve the selectivity of any set! Compactly and sturdily built. Electrically and mechanically right—meeting all requirements of low loss design. Pacent Straight Line Frequency Condensers give you the joy of quick, certain tuning.

Our illustrated catalog describes, in detail, this precision condenser and other Pacent contributions to radio efficiency. May we send YOUR copy.

PACENT ELECTRIC COMPANY, INC.,
91 Seventh Avenue - New York City

Pacent
RADIO ESSENTIALS

GET THESE
SIMPLIFIED BLUEPRINTS
FREE

You can have your choice of any one of eight POPULAR RADIO Simplified Blueprints with your new or renewal subscription for POPULAR RADIO, with which is combined *The Wireless Age*, accompanied by remittance of $3.00. These Blueprints will make it possible for you to build a tested and approved set, while POPULAR RADIO for 12 months will keep you in touch with the progress being made in radio.

You, as a reader of POPULAR RADIO, know the many entertaining, interesting and instructive articles that are published each month. Every issue some new item is sure to attract your attention. We promise that throughout the coming months POPULAR RADIO will hold more and more of interest for Radio Fans.

Ease, Economy and Accuracy in Construction

Simplified Blueprints were prepared under the personal supervision of Laurence M. Cockaday. They make it possible for anyone, without previous knowledge of radio, to construct a highly efficient radio receiver. Each set of Blueprints consists of 3 prints as follows:

Panel Pattern

This Blueprint is the EXACT size of the actual set. So accurate that you need merely lay it on your panel and drill as indicated. You can readily appreciate the convenience of this Blueprint. No scaling or measuring to do, no danger of ruining the panel through faulty calculation.

Instrument Layout

Here again you have an actual size print of each instrument and binding post and its exact location both on the panel and within the cabinet. Even the cabinet structure is clearly shown.

Wiring Diagram

The unusual feature of this Blueprint is that it is an actual size picture diagram of the finished set. Each instrument and other parts appear in exact size and the wires are so clearly traced from one contact to another that you can connect all terminals accurately without even knowing how to read a hook-up diagram.

Set No. 4—"*Cockaday Four-Circuit Tuner with Resistance-Coupled Amplifier*" as described in the October, 1924, issue of Popular Radio.

Set No. 6—"*Cockaday 8-tube Superheterodyne Reflex Receiver*" as described in the January, 1925, issue of Popular Radio.

Set No. 12—"*8-tube Superheterodyne with Single Control*" as described in the October, 1925, issue of Popular Radio.

Set No. 13—"*Raytheon Plate Supply Unit*" as described in the November, 1925, issue of Popular Radio.

Set No. 14—"*The LC-26 Broadcast Receiver*" as described in the December, 1925, issue of Popular Radio.

Set No. 15—"*The Orthophase Receiver*" as described in the February, 1926, issue of Popular Radio.

Set No. 16—"*The S-C All-Wave Receiver*" as described in the March, 1926, issue of Popular Radio.

Set No. 17—"*The Power-pack Amplifier*" as described in the April, 1926, issue of Popular Radio.

Use coupon below; indicate which set of Blueprints you want.

POPULAR RADIO
Dept. 49
627 West 43rd Street New York City

POPULAR RADIO, Dept. 49
627 West 43rd Street, New York City

Enclosed is my remittance of $...... in full payment for subscription, with Blueprints as checked below, FREE.

☐ **Set Number 4**
☐ **Set Number 6**
☐ **Set Number 12**
☐ **Set Number 13**
☐ **Set Number 14**
☐ **Set Number 15**
☐ **Set Number 16**
☐ **Set Number 17**

Name..

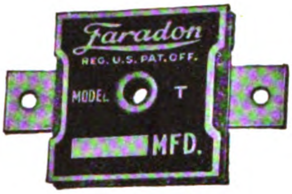
Street..

City..**State**..................

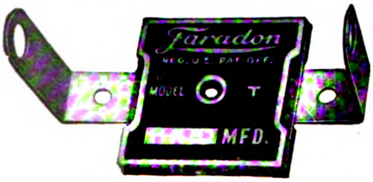
Faradon

ELECTROSTATIC CONDENSERS

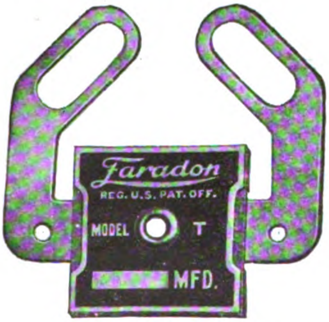
19 YEARS OF SPECIALIZATION IN THE RADIO FIELD



Type I Terminals
For Soldered Connections in Any Portion of Circuit



Type II Terminals
Holds Standard Cartridge Grid Leak—Also Takes Soldered Connections



Type III Terminals
For Transformer or Other Binding Post Mounting—Also Takes Soldered Connections

are behind each Condenser
Trade Marked

Faradon

In Radio Receiving Sets the Biggest Little Things are the FIXED CONDENSERS.

The MODEL T FARADON is furnished in all usual sizes to meet the requirements of Quality Performance.

Quotations covering quantity requirements furnished to
SET MANUFACTURERS
promptly upon request.

Some Important FARADON Users:

U. S. Army—U. S. Navy—U. S. Signal Corps—U. S. Bureau of Standards—General Electric Co.—Radio Corporation of America—Western Electric Company—Tropical Radio Tel. Co.—Westinghouse Electric & Mfg. Co.

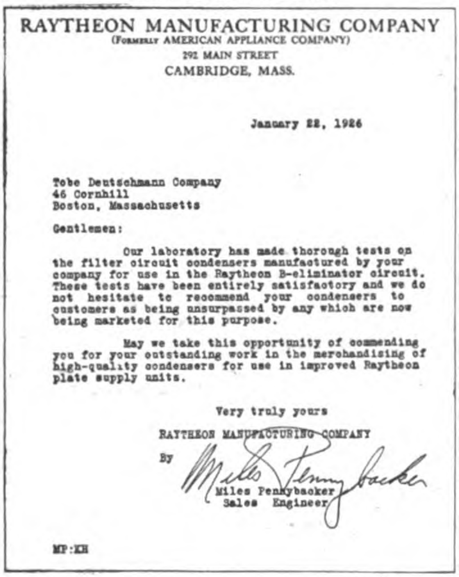
WIRELESS SPECIALTY APPARATUS COMPANY
JAMAICA PLAIN—BOSTON, MASS.

"The Better Condenser"

Maintains Its Leadership

TOBE

READ THIS LETTER!



RAYTHEON MANUFACTURING COMPANY
(FORMERLY AMERICAN APPLIANCE COMPANY)
292 MAIN STREET
CAMBRIDGE, MASS.

January 22, 1926

Tobe Deutschmann Company
46 Cornhill
Boston, Massachusetts

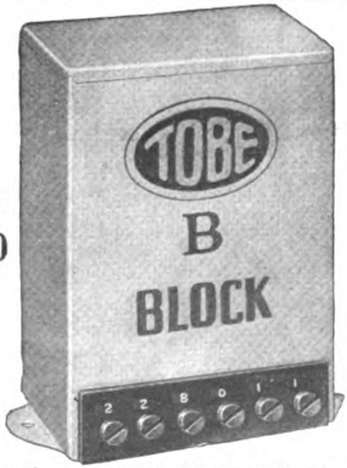
Gentlemen:

Our laboratory has made thorough tests on the filter circuit condensers manufactured by your company for use in the Raytheon B-eliminator circuit. These tests have been entirely satisfactory and we do not hesitate to recommend your condensers to customers as being unsurpassed by any which are now being marketed for this purpose.

May we take this opportunity of commending you for your outstanding work in the merchandising of high-quality condensers for use in improved Raytheon plate supply units.

Very truly yours
RAYTHEON MANUFACTURING COMPANY
By Miles Pennybacker
Miles Pennybacker
Sales Engineer

MP:KH



Price $11.00

Make sure that you get the OFFICIALLY APPROVED RAYTHEON Filter Condenser Block.

The TOBE Condensers have been tested in the laboratory of the Raytheon Manufacturing Company and as a result, they have written the letter reproduced above. It speaks for itself.

The new TOBE B BLOCK contains in one compact silvered metal case the three filter and two by-pass condensers required for the Raytheon B-Eliminator:—one 8 Mfd.,—two 2 Mfd., two 1 Mfd. It saves $2.50 in the cost of parts—saves space—saves wiring. Ask your dealer for "The Better Condensers"

Send for free circuit diagrams of B-Eliminators

Tobe Deutschmann Co., Cornhill, Boston, Mass.

Save 20 to 50%

FREE RADIO CATALOG

NEW 1926 EDITION IS NOW READY

The Barawik Company, pioneers in radio, now offers you through its Radio Catalog and Guide, greater bargains than ever before in standard sets, parts, kits and supplies. No matter what parts you want, for whatever circuit or hook-up—you may prefer, we can supply them to you at substantial savings. Special prices on tubes, batteries, cone speakers, cabinets, etc.

Here are some sample bargains from this bargain catalog:

Complete parts for S-C Receiver	$55.00
" " " LC 26 "	54.50
" " " Hammarlund-Roberts	47.95
" " " McLaughlin 8-tube Super.	82.50
" " " Silver Six	46.50
" " " Silver Autodyne	58.50
" " " Browning-Drake circuit	34.50
Guaranteed 201A type tubes	.98
" 45 V large B batteries	2.35

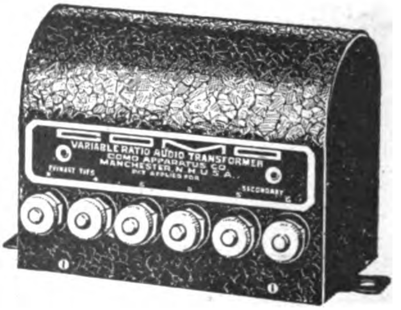
If you are in the market for any of the above, order direct from this ad, enclosing remittance and goods will be shipped you at once. All merchandise guaranteed.

Write today for our New 1926 Radio Catalog and Builders Guide, showing radio's newest creations. Also please include name of another radio fan when writing.

THE BARAWIK COMPANY
103-105 S. Canal St. Chicago, Ill.

COMO

VARIABLE-RATIO AUDIO-TRANSFORMER



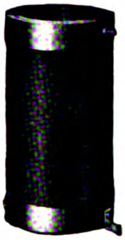
This new unit, made by a pioneer manufacturer of high-grade Radio equipment, gives three ratios in one transformer—4 to 1, 6 to 1, and 8 to 1. It permits varying primary impedance to secure the best results in each stage of audio. It may be used as a high-grade impedance in impedance-coupled audio.

At All Good Dealers

$6.00

Send for descriptive pamphlet V

COMO APPARATUS CO., INC.
Kelley Street Manchester, N. H.



PRECISION OCTAFORM COIL

A new type of inductance used in the Cockaday LC-26 Receiver. The only coil that can be used in this set. Price $5.50.

PRECISION AUTODYNE COUPLER

Used in the Superheterodyne Reflex Receiver described in January 1925 issue of Popular Radio Price $3.50.

PRECISION COIL SET

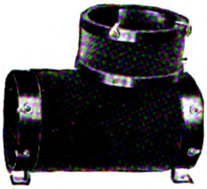
No. 300

For the new Orthophase Receiver described in February Popular Radio. Price, per set of three, $7.50.

COCKADAY COIL $5.50

(New Octaform Base)

The fact that this coil was used in the 4-Circuit Tuner as designed by Mr. Cockaday, is significant recognition of the accuracy and efficiency of Precision Coils.



COMPLETE KITS

EXACTLY THE SAME AS MR. COCKADAY'S LABORATORY MODELS

Insure your getting the same results Mr. Cockaday gets from his Laboratory Models by purchasing kits from us. Our buying department has exceptional facilities for getting the exact parts Mr. Cockaday uses. Write us.

POWER PACK AMPLIFIER

1 Amertran power transformer, type PF-52	$18.00
1 Amertran DeLuxe A. F. Transformer, second stage	10.00
3 Amerchokes, type 854	18.00
2 Dubilier filter condensers, type 769, 2 mfd	7.00
2 Dubilier filter condensers, type 770, 4 mfd	14.00
4 Dubilier filter condensers, type 766, 2 mfd	8.00
1 Aerovox-Craig resistor, type 980	4.00
1 Bradleyohm No. 25—25,000 to 250,000 ohms	2.00
2 Pacent single circuit jacks, No. 61	1.00
2 Benjamin Push-type sockets, No. 9040	$1.50
Bakelite sub-base, 7 x 21 x ¼ inch	4.45
Bakelite binding post strip, 7 x 1 x ¼ inch	.45
Angle brass reinforcement strips for sub-base pr	.90
Angle brass for holding binding post script, pr	.10
Brass brackets for mounting resistor unit M	.35
Brass strip for mounting filter condensers	.35
Complete	$90.10

COCKADAY LC-26 KIT

1 General Radio variometer, type 269, equipped with rheostat knob	$5.30
1 General Radio rheostat, type 214-a, 7 ohms, equipped with rheostat knob	2.25
1 Precision Octaform coil set	5.50
1 Amsco special double unit condenser No. 1814 each section .0003 mfd	6.25
1 Micamold fixed condenser, .00015 mfd	.35
1 Micamold fixed condenser, .00025 mfd	.35
2 Daven resisto-couplers (new type which incorporates .1 mfd. condenser concealed in base)	3.00
1 Amertran DeLuxe transformer, first stage	10.00
Bradleyleak, ¼ to 10 meg	1.85
3 Bradleyunits, ¼ megohm	2.25
1 Bradleyunit, ½ megohm	.75
3 Amperites No. 1a	$3.30
1 Amperite No. 112	1.10
5 Benjamin standard "Cle-ra-tone" sockets	5.00
1 Carter single-circuit jack, No. 101	.70
2 Carter Jack switches, No. 2	2.00
8 Eby binding posts	1.20
1 Fynur vernier control knob and dial	3.50
1 Universal decorated panel, 8x22 inches	7.50
Blueprints	1.00
4 Small brass brackets	1.75
1 Antenna connection block, 1x2 inches	
1 Battery connection block, 1x9 inches	
2 Large brass brackets	
Screws and buss wire	
Solid Walnut Cabinet	17.00
Total	$81.90

COCKADAY 3-TUBE 4-CIRCUIT TUNER

1 Precision Octaform 4-circuit Coil Set	$5.50
1 Lombardi Dual S.L.F. variable condenser (2 sections)	9.50
1 Aerovox mica fixed condenser .00025 mfd	.30
2 Perry audio-frequency transformers	12.00
1 Bradleyleak	1.85
1 Jones seven-point inductance switch	1.50
1 E-Z-stat, 6 ohms	.75
1 Amperite No. 112	$1.10
2 Na-ald De Luxe sockets	1.50
1 Benjamin Claratone socket	1.00
1 Yaxley open-circuit filament jack	.70
1 Gee Haw vernier dial	3.00
1 panel, 7 x 18 inches	2.40
1 baseboard, 6¾ x 16¾ inches	.35
Seven Eby binding posts	1.05
Price Complete (Including panel and baseboard)	$42.50

OTHER KITS IN STOCK

Complete parts for the S-C Receiver described in March Popular Radio	$58.85
Complete parts for the Raytheon "B" Eliminator	$42.05

PRECISION COILS AND KITS ARE ABSOLUTELY GUARANTEED

Send money order today or we will ship C.O.D. upon receipt of your order anywhere in the U. S. A. Dealers—Write for information about the complete Precision Line.

PRECISION COIL CO., INC.

209 Centre Street, New York, N. Y.

SIMPLIFIED BLUEPRINTS

MAKE IT EASY TO BUILD A SET

LAURENCE M. COCKADAY has personally supervised the preparation of *Simplified Blueprints* of eight of POPULAR RADIO's most popular circuits. Each set consists of at least three separate *Actual Size* Blueprints; first a Panel Pattern; second, an Instrument Layout; and third, a Picture Wiring Diagram all simplified in the fullest sense of the word ***because***

The Panel Pattern can be laid on the panel and all holes drilled as indicated. No scaling to do and so accurate there is no danger of ruining the panel through faulty calculation.

The Instrument Layout placed on the sub-base permits you to indicate by pinpricks the exact location of every screw.

The Picture Wiring Diagram gives every instrument in exact size and position with every wire clearly indicated from one contact to the other. With no knowledge of radio symbols you can assemble every part and complete your wiring with no chance of error.

Priced at $1.00 per Set of Three Prints

Set No. 4—"*Cockaday Four-Circuit Tuner with Resistance-Coupled Amplifier*" (five tubes, distortionless, two dials, automatic vacuum tube control, as described in the October, 1924, issue of POPULAR RADIO).

Set No. 6—"*The Cockaday 8-tube Super-heterodyne Reflex Receiver*" (eight tubes, two tuning dials, loop, non-radiating, distortionless, as described in January, 1925, issue of POPULAR RADIO).

Set No. 12—"*8-Tube Superheterodyne with Single Control*" (eight tubes, two straightline variable condensers, as described in October, 1925, issue of POPULAR RADIO).

Set No. 13—"*Raytheon Plate Supply Unit*" (a really dependable method for obtaining a "B" source of supply as described in November, 1925, issue of POPULAR RADIO).

Set No. 14—"*The LC-26 Broadcast Receiver*" (as described in December, 1925, issue of POPULAR RADIO).

Set No. 15—"*The Orthophase Receiver*" (a circuit development using a new principle in radio-frequency amplification, making a receiver with great sensitivity, combined with sharp tuning and ease of operation, as described in February, 1926, issue of POPULAR RADIO).

Set No. 16—"*The S-C All-Wave Receiver*" (equipped with inter-changeable coils so that it has practically an unlimited wavelength range, covering all wavelengths from 50 to 550 meters, as described in March, 1926, issue of POPULAR RADIO).

Set No. 17—"*The Power-Pack Amplifier*" (supplies the "A," "B," and "C" voltages to the high power amplification in the last stage direct from the alternating current lighting lines, as described in April, 1926, issue of POPULAR RADIO).

Full constructional and parts details for these Receiving Sets will be found in the issue of POPULAR RADIO indicated. Back issues of POPULAR RADIO will be furnished at the rate of 35c a copy

Popular Radio

627 West 43d Street **Dept. 44** **New York City**

POPULAR RADIO, Inc., Dept. 44
627 West 43d St., New York City Date..

Enclosed is my remittance of $.................., for which kindly send me Blueprint Set (s) consisting of Panel Pattern, Instrument Layout and Wiring Diagram as checked below:

☐ Set Number 4 ☐ Set Number 12 ☐ Set Number 14 ☐ Set Number 16
☐ Set Number 6 ☐ Set Number 13 ☐ Set Number 15 ☐ Set Number 17

Name..

Address...

City.. State.....................

DEALERS

Write for terms on these fast selling Blueprints. An attractive Display Chart free with orders.

Chief Engineers are Standardizing on Samson Quality Products

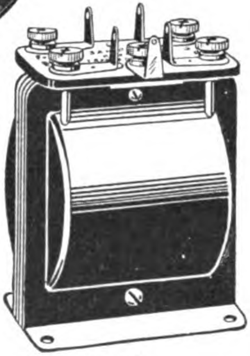
Samson R. F. Choke Coil - $1.50

Helical Winding

In many sets famous for their tone quality you will find the Samson RF Choke Coil shown at the left. It improves the reception of practically any set in which it is used—does not act like a by-pass condenser, but performs the function for which it is designed.

The inherent properties of the patented Samson Helical Winding used assure far less distributed capacity effect—which is the cause of ordinary RF Choke Coils failing to perform their desired functions. A bulletin on the uses of RF Choke Coils is yours for the asking.

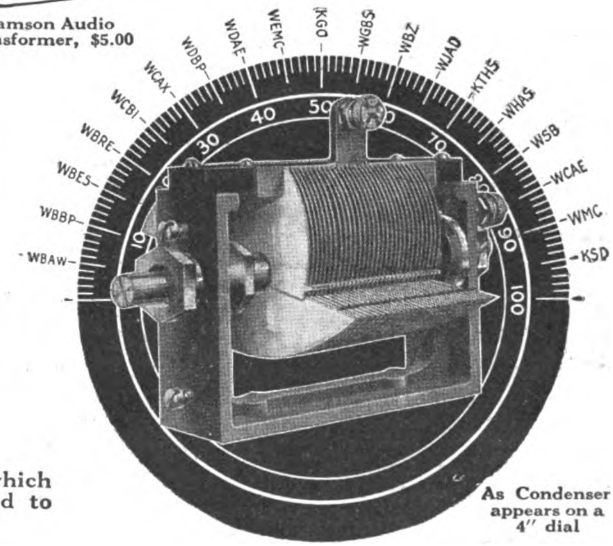
This Helical winding assures practically uniform amplification over entire audible range by the Samson Audio Transformer, shown at the left, which is supplied in 3 to 1 and 6 to 1 ratios.



Samson Audio Transformer, $5.00

The chief engineer of one of the largest concerns manufacturing radio sets specified Samson Transformers last Spring because of their quality. At the end of the 1925 radio season, after selling more than 13,000 sets containing Samson Transformers, the chief engineer reported that to date no Samson Transformer had proven defective in consumers' hands and they are yet to receive their first complaint. A quality product plus *insurance*.

Samson Uniform Frequency Condensers give supreme service because of steel shaft and bronze bearings—heavy ribbed die cast frame—large phosphor bronze helical contact spring, short rigid locked and soldered brass plates and stiff metallic shield. Gold plated stator and rotor plates prevent corrosion. The Samson Uniform Frequency Condenser occupies half to a third the space others do and is capable of gang operation. It has losses lower than laboratory standards and is guaranteed to be accurate within *plus or minus one per cent* of its rated capacity. Other products covered by our literature. Send for it.



As Condenser appears on a 4" dial

Manufacturers with problems which we might assist to solve are invited to write us.

Samson Uniform Frequency Condenser, 500 m.m.f. $9.00, 350 m.m.f. $8.75, 250 m.m.f. $8.50

Samson Electric Company

Manufacturers Since 1882

MEMBER RMA

Sales offices in 30 leading cities

Main offices and Factory, Canton, Mass.

Big Demand for New Circuits

The New S. C. Receiver **Orthophase Receiver**
L. C. 26 Broadcast Receiver **General Radio Universal Receiver**

We Have All the Hard-to-Get Complete

STANDARD PARTS

Either in Kit Form or Separately for All Popular Circuits

THE DEMAND MAKES IT IMPERATIVE YOU SEND YOUR ORDER NOW!

LATEST S. C. RECEIVER

	Total
2 S-M antenna coils: Nos. 110A and detector coil No. 114A, equipped with 2 No. 515 coil sockets	$7.00
2 S-M Slf variable condensers No. 316, equipped with 1 vernier dial No. 801	13.75
4 S-M tube sockets, type 510	2.00
2 Thordarson S-C power transformers	16.00
1 Polymet mica fixed condenser, .002 mfd	.40
1 Polymet mica fixed condenser, .005 mfd	.60
1 Polymet gridleak, 2 megohms	.25
1 Polymet mica fixed condenser, equipped with gridleak clips, .00005 mfd	.45
1 Yaxley rheostat, No. 16K, 6 ohms	1.35
1 Yaxley battery switch No. 10	.50
1 Yaxley jack, type No. 1	.50
1 Yaxley jack, type No. 2	.60
1 Centralab variable resistance, 25,000 ohms	1.50
1 James Jr. midget condenser .00045 mfd	1.50
2 Gleason S-C mounting brackets	.70
1 Belden S-C connecting harness	4.00

COMPLETE PARTS (Including drilled & engraved front panel; 7 x 18 inches. Drilled & engraved sub-panel, 6 1-2 x 17 inches) **$55**

CABINET FOR THIS SET $9.50 EXTRA

MR. LAURENCE COCKADAY'S L. C. 26 RECEIVER

PARTS AS USED BY MR. COCKADAY IN BUILDING HIS LABORATORY SET

	List Price
1 General Radio variometer, type 269, equipped with rheostat knob	$5.30
1 General Radio rheostat, type 214-a, 7 ohms, equipped with rheostat knob	2.25
1 Precision Octaform coil set	5.50
1 Amsco special double unit condenser No. 1814, each section .0003 mfd	6.25
1 Micamold fixed condenser, .00015 mfd	.33
1 Micamold fixed condenser, .00025 mfd	.35
2 Daven resisto-couplers (new type which incorporates .1 mfd condenser in base)	3 00
1 Amertran DeLuxe transformer, first stage	10 00
Bradleyleak 1-4 to 10 meg	1 85
3 Bradleyunits, 1-4 megohm	2 25
1 Bradleyunit, 1-2 megohm	75
3 Amperites No. 1a	3 30
1 Amperite No. 112	1 10
5 Benjamin standard "Cle-ra-tone" sockets	5 00
1 Carter single circuit jack, No. 101	70
2 Carter Jack switches, No. 2	2 00
8 Eby binding posts	1 20
1 Fynur vernier control knob and dial	3 50
4 Small brass brackets 1 Antenna connection block, 1 x 2 inches 1 Battery connection block, 1 x 9 inches 2 large brass brackets	.80

Complete Parts (including 1 Bakelite drilled and engraved Panel 8 x 22") **$59.75**

ORTHOPHASE RECEIVER SPECIAL All the standard parts necessary to build this well known receiver packed and ready to assemble—ONLY— **$55**

WE GUARANTEE IMMEDIATE DELIVERY. THESE SETS WIRED TO ORDER COMPLETE $10.00 EXTRA

WHOLESALE AND RETAIL

HEINS & BOLET, 44 PARK PLACE, NEW YORK

Mail Orders Shipped the Same Day They are Received

FIXED RESISTORS

Micamold

REG.

FIXED CONDENSERS

"Made of Mica and Moulded in genuine Bakelite"

With Micamold Resistors and Condensers you need no clips or mounts—just solder direct to the terminals, thus eliminating point or loose contact and accidental dislodgment of the units.

Micamold Products are moulded in genuine Bakelite and guaranteed within 5% of calibrations and constant in value. They are noiseless, moistureproof and indestructible.

At all good Radio Stores

MICAMOLD RADIO CORP.
Flushing and Porter Aves., Brooklyn, N.Y.

ACCURACY GUARANTEED -VALUES REMAIN CONSTANT

MOULDED UNDER PRESSURE OF 50 TONS

Build Your LC-26

With the Aid of

Popular Radio Blue Prints

It is Easy, Quick and Accurate

The LC-26 is the ideal all-around receiver, combining unusually fine tone quality, selectivity and distance-getting ability, with simplicity of construction and operation. It operates on any antenna from 10 feet to 200 feet long, indoors or out.

In tests at Washington, D. C., the LC-26 brought in over 40 stations in one night, the farthest away being KGW, Portland, Oregon.

At Chicago, Ill., the LC-26 brought in KFI, Los Angeles, every night for a week, and over 60 other stations. WEAF, New York, was heard clearly at eleven o'clock in the morning.

At New Haven, Conn., it brought in WMBF, at Miami Beach, Florida, at 4:00 p.m., as well as New York stations for which New Haven is a dead spot.

All reception on the LC-26 is on the loudspeaker, as it has no phone connection.

By using POPULAR RADIO Blue Prints in building your LC-26, you can save time, eliminate the possibility of error, and make your set exactly like the laboratory models (see page 52).

If your local dealer cannot supply you with Blue Prints of the LC-26, they will be sent postpaid on receipt of $1.00 per set.

A full description of the LC-26, with detailed directions as to how to build it, was published in December POPULAR RADIO.

POPULAR RADIO
Service Bureau 44-A
627 West 43d Street, New York

MAIL THIS COUPON TODAY TO GOLDEN-LEUTZ, INC., 6th & WASHINGTON AVES., LONG ISLAND CITY, N. Y.

GOLDEN-LEUTZ, INC.
6TH & WASHINGTON AVES.
LONG ISLAND CITY, N. Y.

GENTLEMEN:

PLEASE MAIL IMMEDIATELY WHEN READY AND WITHOUT OBLIGATION ON MY PART FULL DESCRIPTIVE LITERATURE ON YOUR NEW LINE INCLUDING

1. STANDARD PLIO 6 A POWERFUL HIGH GRADE MEDIUM PRICED BROADCAST RECEIVER.
2. UNIVERSAL PLIO 6 HAVING THE EXCLUSIVE FEATURE OF TUNING ALL WAVELENGTHS FROM 35 TO 3600 METERS FOR PERFECT BROADCAST RECEPTION.
3. UNIVERSAL SUPER 8 A VERY HIGH GRADE SCIENTIFIC BROADCAST RECEIVER ALSO FOR ALL WAVELENGTHS FROM 35 TO 3600 METERS.
4. UNIVERSAL TRANSOCEANIC THE MOST POWERFUL AND MOST ADVANCED RADIO BROADCAST RECEIVER IN THE WORLD.

CONSUMER ☐ DEALER ☐ JOBBER ☐

INDICATE INTEREST WITH AN "X"

YOURS VERY TRULY

NAME...

ADDRESS...

MYERS

The World On Your Dial

Myers Radio Tubes

Seven Years of Superiority

KNOWN as the original HI-MU tubes before the days of BCL;

Preferred by amateurs and experts before the first popular receiving set was sold;

Progressively improved in construction and performance;

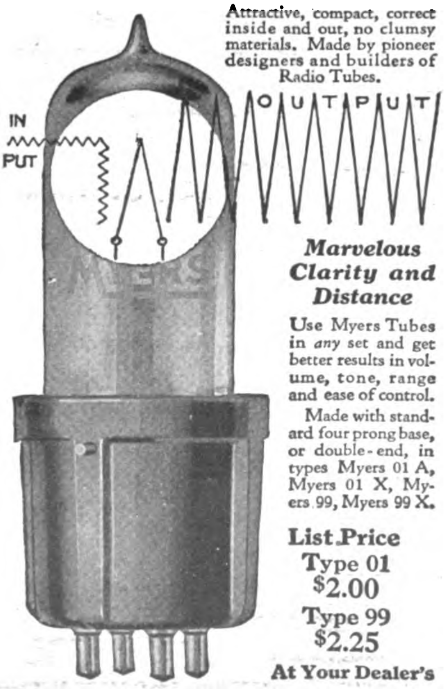
Made in the newest and best equipped plant in America.

Get the World on Your Dial
With Myers Tubes

Low impedance, high amplification constant, high mutual conductance. Best results in any circuit—impedance, resistance or transformer coupled.

At Your Dealer's

Myers Radio Tube Corporation
Cleveland, Ohio



Attractive, compact, correct inside and out, no clumsy materials. Made by pioneer designers and builders of Radio Tubes.

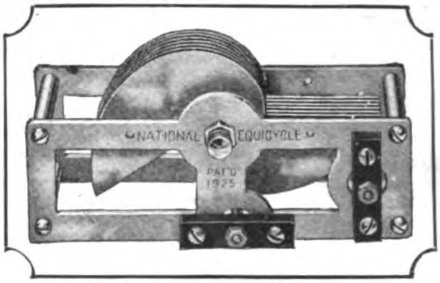
Marvelous Clarity and Distance

Use Myers Tubes in *any* set and get better results in volume, tone, range and ease of control.

Made with standard four prong base, or double-end, in types Myers 01 A, Myers 01 X, Myers 99, Myers 99 X.

List Price
Type 01
$2.00
Type 99
$2.25
At Your Dealer's

—a distinct innovation in the capacity unit field



THE *New* NATIONAL EQUICYCLE Condenser

Patented Feb. 10, 1925

The latest development in straight line frequency control as applied to NATIONAL CONDENSER design.

Increases range of rotation from 180° to 270° permitting more precise adjustment and sharper separation of stations. And accomplishes this without gears, cams or levers.

It has the same electrical efficiency and mechanical ruggedness that have always characterized NATIONAL DX Condensers. Prices:

Made in Two Sizes	With Dials	Without Dials
.0005	$7.00	$5.00
.00025	7.50	5.50

Get the genuine. Insist upon NATIONALS. Your dealer appreciates your patronage and will gladly get them for you. Write for Bulletin 111 *PR.*

NATIONAL COMPANY, INC.
W. A. READY, President
110 Brookline Street Cambridge, Mass.

ALL-AMERICAN
TRADE MARK

Complete
with Raytheon tube, $45

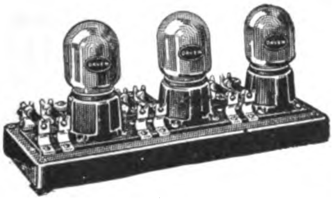
Constant-B

a thoroughly dependable B power—designed to be trouble-proof and permanent.

See it and try it—and remember it is

Radio Built for the Years to Come

"Tune in" the *Lost notes* with DAVEN AMPLIFICATION



YOU will never know the meaning of *full note* reception until you have improved your radio set with Daven Amplification.

It brings to you such perfect *natural toned* reception you feel as though you could reach out and touch the artist.

Simple to install—accurate in tone reproduction — inexpensive — and above all, it insures you against the fear of your radio set becoming obsolete!

Go to your Authorized Daven Service Dealer. He is competent to make the installation.

OTHER DAVEN ACCESSORIES

Amplifier Tubes
Power Tubes
DRF Coils
Amplifier Kits
Resisto-Couplers
Leakadensers
Resistors
Ballast Resistors
Mountings

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DAVEN RADIO CORPORATION

"The Sine of Merit"
Reg. U. S. Pat. Off.

Newark New Jersey

USE THIS FREE COUPON

DAVEN RADIO CORPORATION
153 Summit St., Newark, New Jersey

Please send me the following on Resistance Coupled Amplification.

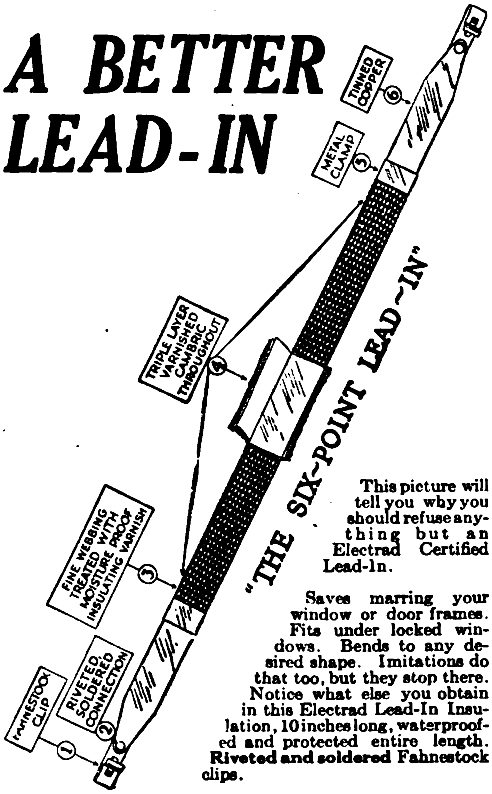
Check the one you prefer. ☐ Resistor Manual 25c. is enclosed ☐ Complete Catalogue *(free)*

Name ....

Address ....

FOR DEALERS: Send your letterhead or card, or this coupon and we will have our nearest distributor communicate with you.

A BETTER LEAD-IN

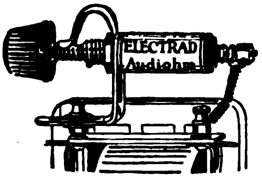

TINNED COPPER
6
METAL CLAMP
5
TRIPLE LAYER VARNISHED CAMBRIC THROUGHOUT
4
FINE WEBBING TREATED WITH MOISTURE PROOF INSULATING VARNISH
3
RIVETED SOLDERED CONNECTION
2
FAHNESTOCK CLIP
1
"THE SIX-POINT LEAD-IN"

This picture will tell you why you should refuse anything but an Electrad Certified Lead-In.

Saves marring your window or door frames. Fits under locked windows. Bends to any desired shape. Imitations do that too, but they stop there. Notice what else you obtain in this Electrad Lead-In Insulation, 10 inches long, waterproofed and protected entire length. **Riveted and soldered Fahnestock clips.**

Sold at all good radio stores and counters. Price 40c. Canada 60c. Ask for it by name. For safety's sake refuse imitations.

For Clearer, Purer Reception Do This



Place an Electrad Audiohm across the secondary of your audio-transformer. Then you will enjoy your radio. Kills distortion, eliminates squeals and howls. Fits all audio transformers. Easy to attach. For sale at good radio stores and counters, $1.50. Canada $2.10

ELECTRAD, INC.

428 Broadway, New York

Makers of Certified Radio Essentials and Accessories: Grid Leaks, Fixed Condensers, By-Pass Condensers, Variohms, Resistances, Rheostats and Potentiometers. Write for catalog. Jacks, Switches, etc.

We Have Succeeded!

in constructing a variable air condenser using

QUARTZ

for insulation so that this finest of all condensers can now grace any man's receiving set.

In the manufacture of Bureau of Standard type of primary standard variable air condensers, we use quartz only for insulation.

In our own laboratory we use variable condensers insulated with quartz only.

The most accurate operating variable air condenser demands quartz for insulation.

Fused silica quartz is the most expensive insulating material and it is the only insulating material in existence that is electrically permanent and of lowest dielectric loss.

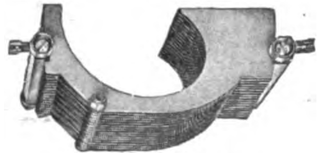
All obstacles to adopt fused silica quartz for insulation in commercial condensers have been conquered, and

We Have Succeeded!

Concentric Straight Line Frequency

Insulated with Quartz. Type 87

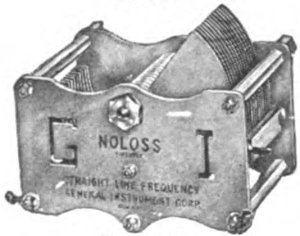
Type	Maximum Capacity mfd.	Price
87 N	.00035	$9.00
87 D	.0005	10.00



Stator

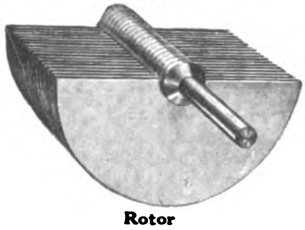
Insulated with Pyrex. Type 80

Type	Maximum Capacity mfd.	Price
80 N	.00035	$5.00
80 D	.0005	6.00



Patented

At your dealers, otherwise send purchase price and you will be supplied postpaid—



Rotor

General Instrument Corporation

Manufacturers of Laboratory Equipment

477 Broadway, New York City

Don't Let Your Tubes Deceive You!

You Can Tell Good Tubes From *Bad* Only By This Scientific Test. SAVES TROUBLE HUNTING—INSURES BETTER RADIO.

Remember one poor tube in your set may be the cause of many difficulties—loss of volume—failure to get distant stations—and other troubles. In less than half a minute this little tester will show you whether a tube is a good, fair or poor amplifier. It will save you hours of trouble hunting. Is invaluable to the set owner who wants the best radio there is in the air.

Sterling

"HOME" TUBE TESTER

THE STERLING MFG. CO.
2831-53 Prospect Ave.
Cleveland, Ohio. Dept. G.

No. R401
$8.50
for testing large tubes

No. R399
$10.00
for testing small tubes

FREE—

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RADIO CATALOG

Just off the press—waiting for you. All the latest sets with special kits to build them. Parts and accessories by well-known manufacturers. Every fan needs this latest guide-book to the best in radio. Write for your FREE copy.

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Dept. PR6

WRS IS EARLIEST WITH THE LATEST!

READY FOR IMMEDIATE DELIVERY
POWER UNIT

Parts used in building the Laboratory Model of the "Power Unit"

1	Amertran power transformer, type PF-52	$18.00
1	Amertran De Luxe A. F. transformer for second stage	10.00
3	Amerchokes, type 854	18.00
2	Dubilier filter condensers, type 769, 2 mfd. (working voltage 400 volts D.C.)	7.00
	Dubilier filter condensers, type 770, 4 mfd. (working voltage 400 volts D.C.)	4.00
4	Dubilier filter condensers, type 766, 2 mfd. (working voltage 160 volts D.C.)	8.00
1	Ward-Leonard vitrohm resistor unit, size C	8.50
or	or	or
	Aerovox Craig resistor, type 98	4.00
1	Bradleyohm No. 25 25,000 to 250,000 ohms	2.00
2	Pacent single-circuit jacks, No. 61	1.00
2	Benjamin push-type sockets, No. 9040	1.50
	Bakelite sub-base, 7 x 21 x 1-4 inch	6.45
	Bakelite binding post strip, 7x1x1-4 inch	.45
	Angle brass reinforcement strips for sub-base	
	Angle brass for holding binding post strip. Pair	.10
	Brass brackets for mounting resistor unit M. Pair	.35
	Brass strip for mounting filter condensers	.35

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		List Prices
1	S-C Belden Wiring Harness	$ 4.00
1	Centralab Resistance, No. 25 M. S. R.	2.00
1	Polymet, or Micamold or Dubilier .00015 condenser with grid leak clips	.45
1	Polymet, or Micamold or Dubilier .002 condenser	.40
1	Polymet, or Micamold or Dubilier .006 condenser	.60
1	2 megohm leak	.25
1	Drilled and Engraved Front Panel	4.50
1	Drilled and Engraved Sub-panel	2.50
2	Silver Marshall No. 316, .00035 Condensers	11.50
2	Silver Marshall No. 515 Coil sockets	2.00
1	" " No. 801 Vernier Dial	2.00
1	Silver Marshall No. 110A Coil	2.50
1	" " No. 114A Coil	2.50
4	" " No. 510 Tube Sockets	2.00
1	" " No. 340 Condenser .000025	1.50
1	Silver Marshall No. 540 Mounting Brackets	.70
2	Thordarson Equiformers	16.00
1	Yaxley No. 16K 6 ohm Rheostat	1.35
1	" No. 1 Jack	.60
1	" No. 2 Jack	.60
1	" No. 10 Switch	.50
1	Box of screws, consisting of 12-¾" 6/32 R. H. Brass screws (Round-head) 8-½" 6/32 R. H. Brass screws (Round-head) 4-1" 6/32 F. H. Brass screws (Flat Head) 24 6/32 brass nuts	.50
	Factory Sealed Kit	$59.25

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Wholesale Distributors of RADIO APPARATUS

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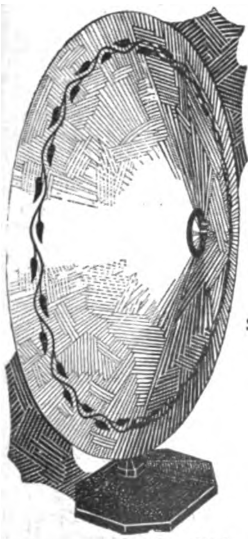

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Simply send name and address and the complete outfit will be sent you by return mail. You pay the postman only $10 in full payment. If you aren't absolutely delighted—simply return the parts within 10 days and your money will be instantly refunded. You take no risk. Write NOW!

Scientific Radio Laboratories
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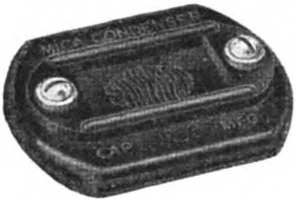
"He didn't need new tubes!"

SANGAMO
Accurate Condensers

(Solidly molded in impervious Bakelite)



saved $15

FOR several weeks his receiving set had been disappointing. Previously, it had been a constant delight, but now programs came in so weak his family had to use headsets — they couldn't hear the loud-speaker clearly. Nothing but local stations. Friends said he needed new tubes, new batteries, new aerial, new this-and-that; all with a fine friendly disregard for the cost.

Then a *real* radio expert gave him good advice. "*Trouble may be in your fixed condensers. Moisture creeps in at exposed edges and changes their capacity. This upsets the electrical balance; there is resistance where there ought to be exact capacity, and your reception is spoiled, both in quality and volume.*

"Try Sangamo Mica Condensers. Their accuracy is guaranteed, and the solid, seamless bakelite jacket prevents the capacity from ever being affected by moisture, fumes, soldering heat, or any other cause of condenser troubles."

Putting in these accurate Sangamo Condensers increased volume, cleared up reception, brought in DX and saved a waste of money for new accessories. Such a little, inexpensive part —but tremendously important! Any real expert will tell you so.

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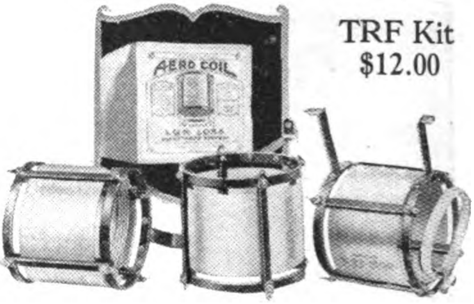

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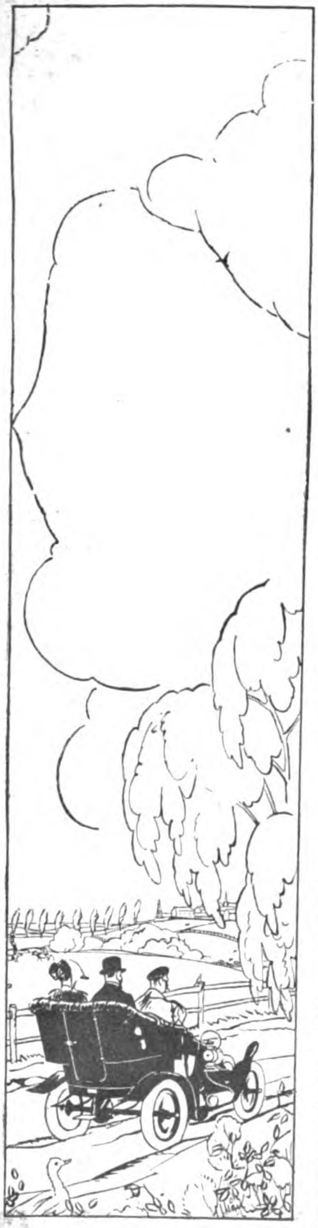

No doubt you remember the first automobile you ever saw. Perhaps you'll remember, too, that it bore a little tank marked "Prest-O-Lite" . . . for Prest-O-Lite gave the motor-car its first dependable eyes.

And it is this same company, which has served the automotive industry so successfully for more than twenty years, that today serves radio with a dependable, long-lived battery, *of special design*, that brings out the best in any set.

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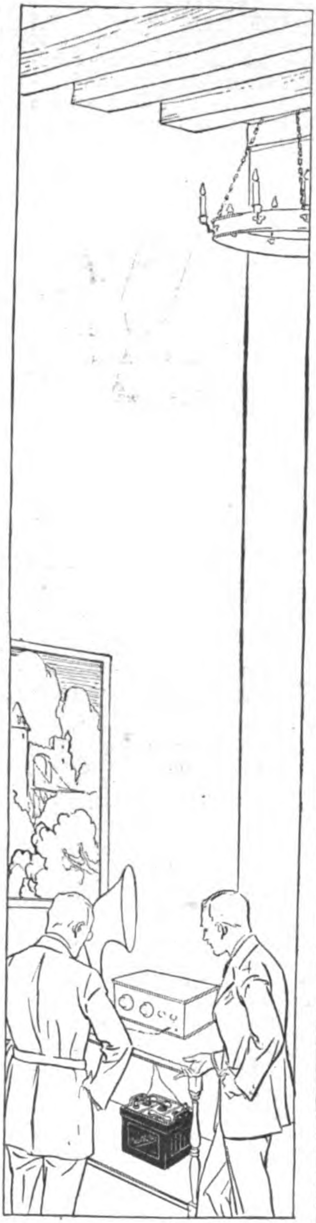

Designed especially for radio

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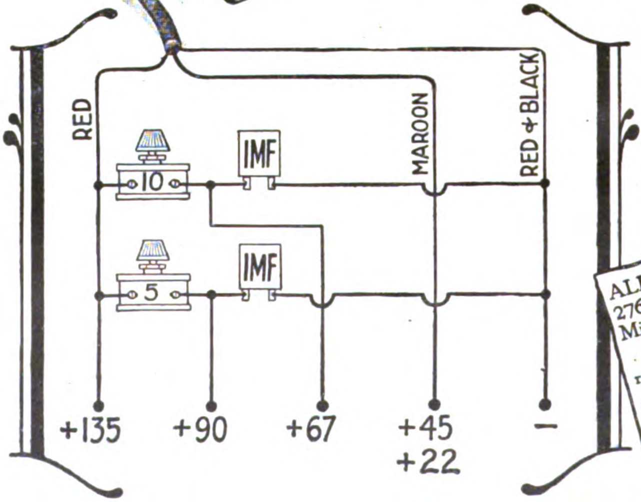
The Bradleyohm is used as standard equipment in the Acme B-Power Supply and most other B-Battery eliminators provided with voltage control. Silent voltage control is thereby assured.

Insist on Genuine Allen-Bradley Products Sold in Checkered Cartons

How to Get Extra Voltage Taps from Your B-Eliminator

MANY radio receivers are provided with several B-Battery terminals for detector, amplifier and radio frequency tubes. To provide the extra voltage taps from B-battery eliminators, such as the Acme B-Power Supply unit, is a simple matter. The diagram below shows the method of connecting the necessary Bradleyohms and condensers.

A Bradleyohm No. 10 for the 67-volt connection and a Bradleyohm No. 5 for the 90-volt connection provide marvelously smooth control over a wide range for these terminals. The condensers may be larger if desired, especially when used with audio-frequency taps. The standard Bradleyohm in the eliminator gives sufficient range for the detector plate voltage. Your dealer can supply you with Bradleyohms and condensers. Try these connections tonight and improve your receiving set.



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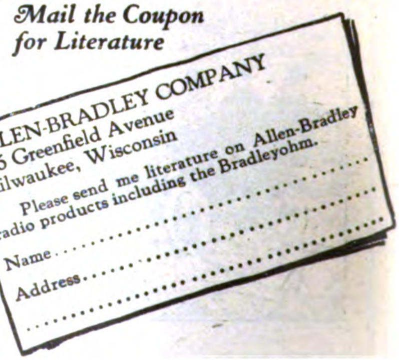

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Please send me literature on Allen-Bradley radio products including the Bradleyohm.

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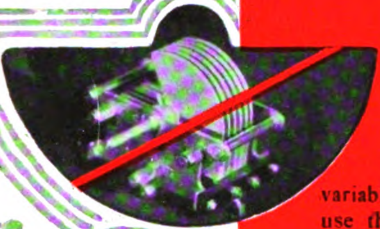

The Taper Plate
Type "E"
with straight frequency
tuning characteristics

Old Friends
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are far more dependable than strangers.

The logical plate shape of a rotary variable condenser is semicircular, and to use them to best advantage, they should not be cut away to any extent.

Cardwell Taper Plate Type "E" condensers have the old familiar plate shape, but have a straight frequency tuning characteristic. The Type "C" approaches straight frequency at minimum but gives more separation at maximum.

They are priced the same—the .0005 mfd. capacity lists at $5.00, and others, proportionately.

The Allen D. Cardwell Mfg. Corp.
81 PROSPECT STREET
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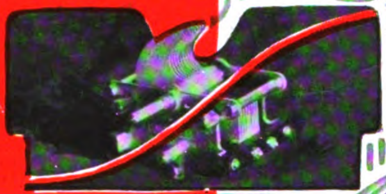
The Type "C" has a
modified straight wave
length tuning curve



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Condensers

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